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Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

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Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

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ABSTRACT

This Remedial Action Work Plan identifies the approach and requirements for implementing monitored natural attenuation as the distal zone remedy for Test Area North, Operable Unit 1-07B at the Idaho National Engineering and Environmental Laboratory. This remedy is being implemented in concert with in situ bioremediation as the remedy for the hot spot, and pump-and-treat is being implemented as the remedy for the medial zone. An operations, maintenance, and monitoring plan will be prepared as a separate submittal to implement the requirements detailed in this Remedial Action Work Plan.

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ACRONYMS

AA	alternative action
ARAR	applicable or relevant and appropriate requirement
bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
D&D	decontamination and decommissioning
DCE	dichloroethene
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
DQO	data quality objective
DS	decision statement
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
FFA/CO	Federal Facility Agreement and Consent Order
FLUTe™	Flexible Liner Underground Technology
FY	fiscal year
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
ISB	in situ bioremediation
MCL	maximum contaminant level
MNA	monitored natural attenuation
NPTF	New Pump and Treat Facility
OU	operable unit

PCE	tetrachloroethene
PLN	plan
PSQ	principal study question
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act of 1986
SRPA	Snake River Plain Aquifer
TAN	Test Area North
TBD	to be determined
TCE	trichloroethene
TSF	Technical Support Facility
USC	United States Code
USGS	United States Geological Survey
VC	vinyl chloride
VOC	volatile organic compound
WAG	waste area group

Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

1. INTRODUCTION

This Remedial Action Work Plan has been prepared in accordance with the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) by the U.S. Department of Energy Idaho Operations Office (DOE-ID). The plan addresses the implementation of monitored natural attenuation (MNA) at Test Area North (TAN) as the remedy for the distal portion of the contaminated groundwater plume associated with the Technical Support Facility (TSF) injection well (TSF-05). The groundwater plume that emanates from the TSF injection well has been designated as Operable Unit (OU) 1-07B. This Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.) remedial action will proceed in accordance with the signed *Record of Decision Amendment—Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (DOE-ID 2001a). The *Remedial Design/Remedial Action Scope of Work Test Area North Final Groundwater Remediation Operable Unit 1-07B* (DOE-ID 2001b) identifies and describes the scope, schedule, and budget the Agencies have agreed are necessary for implementing this remedial action (in accordance with the Record of Decision Amendment [DOE-ID 2001a]).

The Record of Decision Amendment (DOE-ID 2001a) modifies the original remedy for OU 1-07 Bat TAN. The modification was chosen in accordance with CERCLA (42 USC § 9601 et seq.), as amended by the "Superfund Amendments and Reauthorization Act of 1986 (SARA)" (Public Law 99-499), and to the extent practicable, 40 Code of Federal Regulations (CFR) 300, "National Oil and Hazardous Substances Pollution Contingency Plan." The documents that form the basis for the decisions made in the Record of Decision Amendment (DOE-ID 2001a) are contained in the Administrative Record for OU 1-07B. This decision satisfies the requirements of the Federal Facility Agreement and Consent Order (FFA/CO) entered into by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Idaho Department of Environmental Quality (IDEQ).

1.1 Remedial Action Summary

The Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b) defines the scope, schedule, and budget for implementing the OU 1-07B final remedial action, as required by CERCLA (42 USC § 9601 et seq.) and the FFA/CO (DOE-ID 1991) and in accordance with the Record of Decision Amendment (DOE-ID 2001a). The final remedy for OU 1-07B cleanup combines in situ bioremediation (ISB) for hot spot restoration and MNA for distal zone restoration with pump-and-treat—selected in the Record of Decision—Declaration for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites Final Remedial Action Operable Unit 1-07B, Waste Area Group 1 (DOE-ID 1995)—for the medial zone, providing a comprehensive approach to contaminant plume restoration. The remedy also includes groundwater monitoring and institutional controls. The OU 1-07B remedy will prevent current and future exposure of workers, the public, and the environment to contaminated groundwater at the TSF injection well site. Table 1-1 lists the contaminants of concern (COCs) near the TSF-05 injection well.

Table 1-1. Contaminants of concern near the TSF-05 injection well.

Contaminant	Maximum Concentrations[a]	Federal Drinking Water Standard
VOLATILE ORGANIC COMPOUNDS		
TCE	12,000–32,000 µg/L	5 µg/L
PCE	110 µg/L	5 µg/L
cis-1,2-DCE	3,200–7,500 µg/L	70 µg/L
trans-1,2-DCE	1,300–3,900 µg/L	100 µg/L
RADIONUCLIDES		
Tritium	14,900–15,300 pCi/L[b]	20,000 pCi/L
Strontium-90	530–1,880 pCi/L	8 pCi/L
Cesium-137	1,600–2,150 pCi/L	119 pCi/L[c]
Uranium-234	5.2–7.7 pCi/L[b]	27 pCi/L[d]

µg/L = micrograms per liter; pCi/L = picocuries per liter; mrem/yr = millirem per year; L/day = liter per day
a. The concentration range is taken from measured groundwater concentrations at the TSF-05 injection well (INEEL 1999a).
b. Maximum concentrations of tritium and U-234 are below federal drinking water standards and baseline risk calculations indicate cancer risk of 3×10^{-6}. While this risk is smaller than 1×10^{-4}, both tritium and U-234 are included as COCs as a comprehensive plume management strategy.
c. The MCL for Cs-137 is derived from a limit of 4-mrem/yr cumulative dose equivalent to the public, assuming a lifetime intake of 2 L/day of water.

The federal drinking water standard for U-234 is for the U-234, -235, and -238 series.
The data from this table were taken from the *Record of Decision Amendment—Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (DOE-ID 2001a).

COC = contaminant of concern
DCE = dichloroethene
INEEL = Idaho National Engineering and Environmental Laboratory
MCL = maximum contaminant level
PCE = tetrachloroethene
TCE = trichloroethene
TSF = Technical Support Facility

This remedial action will permanently reduce the toxicity, mobility, and volume of the contamination at the site. The remedy's components for restoration of the OU 1-07B hot spot (trichloroethene [TCE] concentrations exceeding 20,000 µg/L), medial zone (TCE concentrations between 1,000 and 20,000 µg/L), and distal zone (TCE concentrations between 5 and 1,000 µg/L) of the contaminant plume (illustrated conceptually in Figure 1-1) include:

- **Hot Spot**—In situ bioremediation promotes bacterial growth by supplying essential nutrients to bacteria that naturally occur in the aquifer and are able to break down contaminants. An amendment (such as sodium lactate or molasses) is injected into the secondary source area through the TSF-05 injection well or other wells in the immediate vicinity. Amendment injections increase the number of bacteria, thereby increasing the rate at which the volatile organic compounds (VOCs) break down into harmless compounds. The amendment supply is distributed as needed, and the treatment system operates year-round.

- **Medial Zone**—Pump and treat involves extraction of contaminated groundwater, treatment through air strippers, and re-injection of treated groundwater. Air stripping is a process that brings clean air into close contact with contaminated liquid allowing the VOC contaminants to pass from the liquid into the air, where they quickly evaporate. Concentrations of all radionuclides, with the exception of strontium-90, presently are below maximum contaminant levels (MCLs) and do not require treatment. Strontium-90 concentrations will be below MCLs at the end of the restoration timeframe. In accordance with the original remedy selected in the Record of Decision (DOE-ID 1995), construction of the New Pump and Treat Facility (NPTF) in the medial zone was completed in January 2001. The facility started routine operations on October 1, 2001.

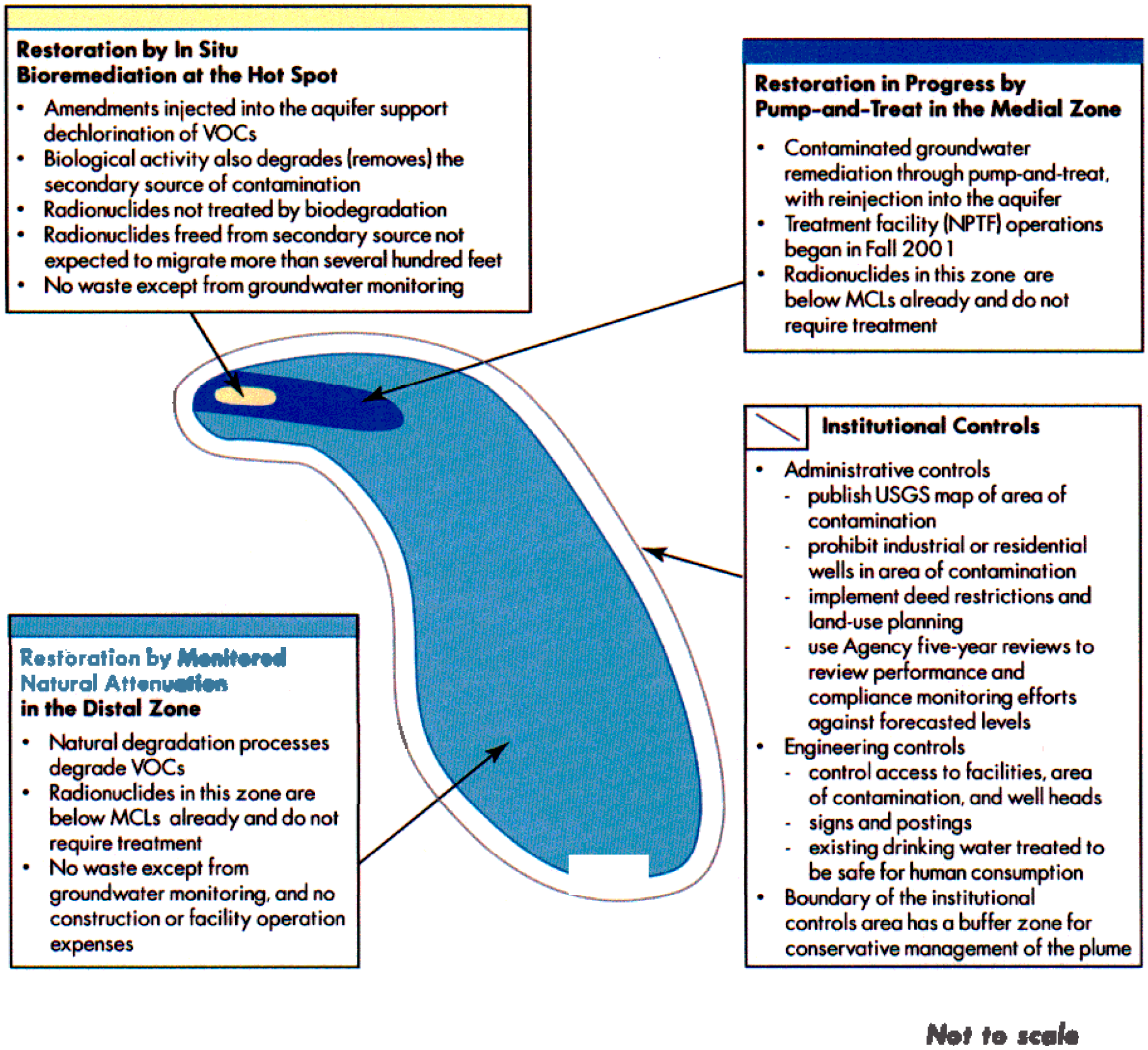


Figure 1-1. Conceptual illustration of the amended remedy's components for restoration of Operable Unit 1-07B.

- **Distal Zone**—Natural attenuation is the sum of the physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Monitored natural attenuation includes groundwater monitoring with annual performance reviews for the first 5 years to compare actual natural degradation rates to predicted degradation rates, followed by additional periodic reviews thereafter at a frequency to be decided by the Agencies.

- **Institutional Controls**—Engineering and administrative controls will be put in place to protect current and future users from health risks associated with groundwater contamination. During the early part of the restoration timeframe, the contaminant plume continues to increase slowly in size until the natural attenuation process overtakes it. Modeling suggests that growth of the distal zone of up to 30% might occur, reaching its maximum size in about 2027 (as defined by the 5-ppb TCE isopleth). However, since institutional controls will be in place, there will be no change in risk to human health or to ecological receptors. Under this alternative, continued groundwater monitoring and computer modeling will be used to track the plume boundary; the institutional control area will be modified, as required, to maintain a conservative buffer zone around the contaminant plume area. The groundwater-monitoring network also will be expanded, as required, to provide TCE concentration data needed to monitor plume expansion.

- **Monitoring**—Groundwater monitoring will be conducted throughout the plume, with samples analyzed to determine the progress of the remedy. Water levels will be measured to verify the NPTF's capability to contain and treat the contaminants in the medial zone.
- **Contingencies**—Contingencies identified under the remedy include:
  - For the medial zone, monitoring wells located upgradient of the NPTF will be monitored on a routine basis to ensure that concentrations of radionuclides in the groundwater remain low. If monitoring indicates that the radionuclide concentrations in the NPTF effluent would exceed MCLs, then the Air Stripper Treatment Unit—which is located between the hot spot and the NPTF but not currently operating—will be used to prevent those radionuclides from traveling down gradient to the NPTF.
  - For the distal zone, if the Agencies determine that MNA will not restore the plume's distal zone within the restoration timeframe, pump-and-treat units will be designed, constructed, and operated in the distal zone for remediation of the plume. The contingency remedy also will be invoked if the required monitoring necessary for MNA is not performed.

Under the remedy, the concentrations of the radionuclide COCs in the hot spot and medial zone will meet the Record of Decision's remedial action objectives (RAOs) within the remedial timeframe through natural attenuation processes. Concentrations of the radionuclide COCs in the distal zone already meet the RAOs. The groundwater-monitoring program will include monitoring the attenuation of radionuclide COCs in the hot spot and the medial zone. If monitoring indicates that the radionuclide concentrations in NPTF effluent will exceed MCLs, then the medial zone contingency will be implemented. The frequency of monitoring at selected medial zone and distal zone locations depends on the potential risk of exceeding MCLs in the NPTF effluent. The Agencies will use the monitoring results to determine appropriate responses.

1.2 Scope of the Monitored Natural Attenuation Remedial Action

This Remedial Action Work Plan outlines a comprehensive process that follows the governing CERCLA and FFA/CO requirements for implementing MNA at TAN. This systematic process integrates project team input and Agency input at critical milestones in accordance with the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b). This Remedial Action Work Plan was developed in concert with several supporting reports to document the basis for long-term MNA operations. The plan identifies and establishes the MNA technical basis, the monitoring and evaluation requirements, the applicable or relevant and appropriate requirements (ARARs), and the requirements for operation, monitoring, and reporting. Supporting documentation—including the *Monitored Natural Attenuation Operations, Monitoring, and Maintenance Plan for Test Area North, Operable Unit 1-07B* (DOE-ID 2003a)—provides technical methods, procedures, and protocols for implementing the requirements of this Remedial Action Work Plan. Requirements for several key areas are summarized in the following subsections. These requirements, including the compliance and performance requirements set forth in Section 2, are established to guide the implementation of the remedial action and to ensure that the RAOs are met.

1.2.1 Technical Basis for Selection of Monitored Natural Attenuation

This Remedial Action Work Plan provides the problem statement and technical basis necessary to develop MNA technical requirements. The MNA technical requirements are established to bracket the key monitoring parameters that are necessary for the MNA system to achieve the RAOs. This Remedial Action Work Plan documents the requirements that the Agencies have agreed are the MNA technical basis.

1.2.2 Evaluation Requirements for Monitored Natural Attenuation Effectiveness

This Remedial Action Work Plan develops requirements for evaluating the effectiveness of MNA to ensure that the remedial action requirements are being met.

1.2.3 Agency Remedial Design/Remedial Action Review and Approval

The CERCLA and FFA/CO process, the Record of Decision (DOE-ID 1995), and the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b) require Agency input, review, and concurrence upon completion of certain actions and prior to starting other actions. This Remedial Action Work Plan integrates project team and Agency review, inspection, and input during the process of implementing this remedial action and defines the objectives, procedures, and process by which the Agencies and the project team will review and concur with the remedial action. The project team will review the initial effectiveness and continued progress of the remedial action over time. In addition, this Remedial Action Work Plan presents the process by which the Agencies can concur that the remedial action is operational and functional. This process will be comprised of a shakedown and performance operational period with clear objectives and measurable performance criteria, an operational and monitoring strategy showing attainment of the stated objectives, and the preparation of a MNA remedial action report. This process will include requirements for Agency prefinal and final inspections, if required.

1.2.4 Infrastructure and Construction

The MNA remedial action principally uses existing infrastructure; however, minimal construction work might be required to maintain an effective monitoring network. This Remedial Action Work Plan discusses foreseeable upgrades to the existing infrastructure, and it identifies and defines activities, inspections, and other requirements necessary to ensure that the remedial construction meets regulatory requirements.

1.2.5 Monitored Natural Attenuation Groundwater Monitoring Operations

This Remedial Action Work Plan establishes requirements for a groundwater-monitoring strategy that will provide the data necessary to evaluate MNA's effectiveness. This will include defining the requirements for procedures, protocols, and processes that will govern routine operations. This Remedial Action Work Plan establishes the data quality objectives (DQOs) and the quantity, quality, and type of analysis necessary to measure performance objectively.

1.2.6 Agency Remedy Performance Review

This Remedial Action Work Plan lays out the basis by which the Agencies will perform remedy performance reviews, establish the basis by which performance will be measured, and delineate the process, format, and schedule of reports, inspections, and reviews.

2. REMEDIAL ACTION OBJECTIVES

Remedial action objectives were defined in the Record of Decision (DOE-ID 1995) to specify expected remedy performance during implementation of the three phases of the Record of Decision remedy. One RAO was defined for each of the three phases: Phase A, Phase B, and Phase C. A separate RAO was defined for the institutional controls to ensure that the controls remained in place during the remedial action's life. Changes described in the *Explanation of Significant Differences from the Record of Decision for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (INEEL 1997) and results of the treatability studies led to a revision of the Phase C RAOs. These modified Phase C RAOs have been adopted as the final RAOs in the Record of Decision Amendment (DOE-ID 2001a), as discussed in Section 2.1.

2.1 Remedial Action Objectives Defined in the 2001 Amendment to the 1995 Record of Decision

Changes and results documented in the Explanation of Significant Differences (INEEL 1997) and the *Field Demonstration Report, Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2000) led to a refinement of the Phase C RAOs that were adopted as the final RAOs in the Record of Decision Amendment (DOE-ID 2001a). The Agencies agreed that the following are the final RAOs for the entire contaminant plume:

- Restore the contaminated aquifer groundwater by 2095 (100 years from the signature of the Record of Decision [DOE-ID 1995]) by reducing all COCs to below MCLs and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use and, for noncarcinogens, until the cumulative hazard index is less than 1.

- For aboveground treatment processes in which treated effluent will be re-injected into the aquifer, reduce the VOC concentrations to below MCLs and a 1×10^{-5} total risk-based level.

- Implement institutional controls to protect current and future users from health risks associated with (1) ingestion or inhalation of, or dermal contact with, contaminants in concentrations greater than the MCLs; (2) contaminants with greater than a 1×10^{-4} cumulative carcinogenic risk-based concentration; or (3) a cumulative hazard index of greater than 1, whichever is more restrictive. The institutional controls shall be maintained until all COC concentrations are below MCLs and until the cumulative carcinogenic risk-based level is less than 1×10^{-4} and, for noncarcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

Restoration of the hot spot under the remedy will not directly affect radionuclide concentrations in the groundwater. The radionuclides' geochemical behavior in the subsurface acts to bind them to soil and rock in the area where they now are located. This behavior will continue to prevent them from migrating beyond the vicinity of the hot spot and from being available to future drinking water users. This behavior supports the presumption that, throughout the restoration period, radionuclide concentrations in water extracted from the aquifer down gradient from the hot spot will remain below MCLs and the 1×10^{-4} cumulative carcinogenic risk-based level, and for noncarcinogens, the cumulative hazard index will remain less than 1. Estimates of radionuclide attenuation by sorption and radioactive decay indicate that Cs-137 and Sr-90 will meet RAOs throughout the contaminant plume by 2095. Sorption of radionuclides from the dissolved phase to subsurface materials prevents these radionuclides from being present in the drinking water of future users. Currently, the remaining radionuclides (U-234 and tritium) are below MCLs and the 1×10^{-4} cumulative carcinogenic risk-based level.

2.2 Performance and Compliance Objectives for Monitored Natural Attenuation

The general performance and compliance monitoring objectives for MNA consist of demonstrating meaningful progress toward restoring the distal zone of the contaminated aquifer groundwater by 2095 (100 years from the signature of the Record of Decision [DOE-ID 1995]) by reducing all COCs to below MCLs and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use, and until the cumulative hazard index is less than 1 for noncarcinogens. These monitoring objectives will be met by collecting monitoring data that demonstrate restoration of the plume by 2095. These objectives are divided into two specific compliance objectives and two performance objectives, which are described below.

Compliance objectives consist of the following:

- Conduct groundwater monitoring at all MNA performance-monitoring wells at a frequency and duration sufficient to demonstrate that the remedy is operational, functional, and effective
- Demonstrate at the end of the remedial action period that RAOs for groundwater have been attained.

Performance objectives consist of the following:

- Monitor whether the natural attenuation process continues to trend toward the RAOs for the distal zone of the plume
- Monitor plume expansion.

2.3 Implementation Strategy for Monitored Natural Attenuation Groundwater Monitoring

The strategy to implement MNA at OU 1-07B is to divide the groundwater-monitoring program into three distinct monitoring zones and two operational phases. The boundary of each monitoring zone is based on the expected time that will be required to identify concentration trends for wells within that zone and to confirm that TCE is being transported and degraded as expected. Zone 1 is the upgradient portion of the plume, where peak breakthrough is thought to have already occurred based on previous modeling studies. In Zone 1, confirmatory data are expected to be obtained within approximately 10 years. Zone 2 is the down gradient portion of the plume, where confirmatory concentration trends might require 20 years or more to collect. Zone 3 is the area outside the down gradient extent of the plume, where groundwater data will be used to monitor plume expansion. Figure 2-1 illustrates the three zones.

The first operational phase, "Performance Operations," allows for a period of annual data collection and analysis to confirm the remedy's effectiveness. The second phase, "Long-Term Operations," consists of confirmatory monitoring to track progress toward achieving RAOs for the duration of the 100-year operational period. Table 2-1 summarizes the required activities and deliverables for each phase.

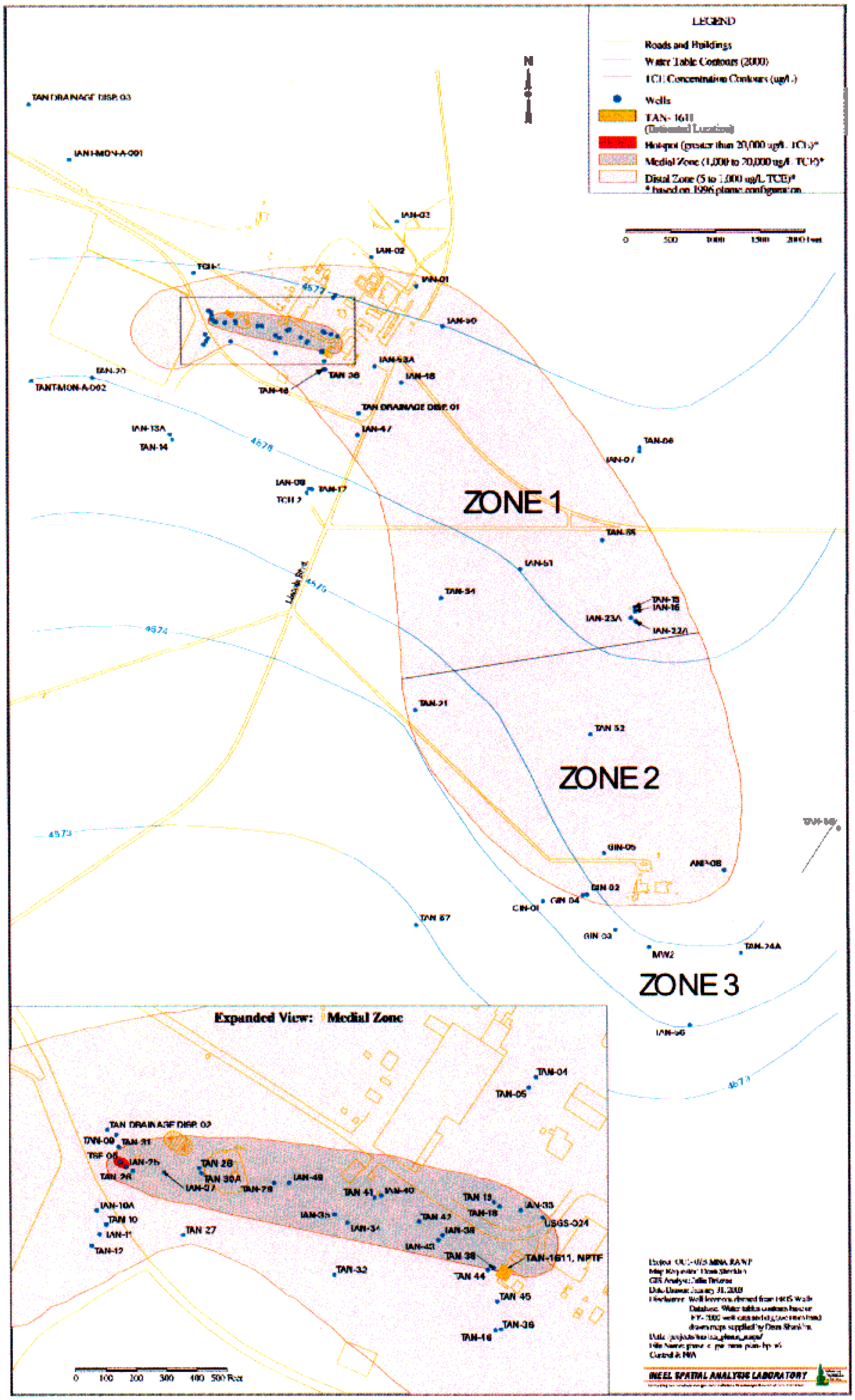


Figure 2-1. Approximate extent of the Test Area North trichloroethene plume, showing the hot spot immediately adjacent to the TSF-05 injection well (trichloroethene concentrations exceeding 20,000 µg/L), medial zone (trichloroethene concentrations between 1,000 and 20,000 µg/L), and distal zone (trichloroethene concentrations between 5 and 1,000 µg/L). To implement the monitoring and evaluation strategy for monitored natural attenuation, three zones are delineated based on the expected time required to verify the remedy's performance in different areas of the plume.

Table 2-1. Summary of required activities for the monitored-natural-attenuation remedial action.

Operations Phase	Required Activities	Deliverable
Performance operations	Calibrate numerical TCE fate and transport model using revised degradation rate and available data in accordance with the requirements of this report (Section 5).	Model Verification Report.
	Evaluate concentration data to determine whether COCs are being attenuated as predicted in Zone 1.	Zone 1 Remedial Action Report, which includes a determination that the remedy is operational and functional in Zone 1, with technical justification.
	Evaluate concentration data to determine whether COCs are being attenuated as predicted in Zone 2.	Zone 2 Remedial Action Report, which includes a determination that the remedy is operational and functional in Zone 2, with technical justification.
	Investigate degradation mechanism via probe studies according to the requirements of this report (Section 5).	This report could be combined with the Remedial Action Report for Zone 1 and submitted early, should the monitoring data and mechanism studies support the conclusion that MNA is operational and functional throughout the plume.
	Collect and analyze groundwater samples according to the requirements of this report (Section 7).	Annual Data Summary Report to document monitoring activities.
Long-term operations	Evaluate concentration data to verify that plume expansion does not exceed 30%, in accordance with the requirements of this report (Section 5).	Annual Data Summary Report to document monitoring activities.
	Collect/analyze samples in accordance with the requirements of this report (Section 7). Evaluate concentration data to determine whether COCs are being attenuated as predicted.	Periodic data summary report to support CERCLA 5-year remedy performance reviews.
	At the end of the remedy, demonstrate that the RAOs have been achieved.	Final Operations Monitoring and Maintenance Report

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
COC = contaminant of concern
MNA = monitored natural attenuation
RAO = remedial action objective
TCE = trichloroethene

2.3.1 Performance Operations Phase

The performance operations phase will consist of a period of annual sampling and analysis activities to confirm that TCE is being transported and degraded as expected. The duration of this phase is variable, based on the results of the data collected. For Zone 1, it is expected that sufficient data can be collected within 10 years to confirm or deny that peak breakthrough of TCE has occurred at a time sufficient to meet RAOs. A Remedial Action Report is scheduled for Agency review and approval in 2013.

This report will include analyses of the monitoring data and evidence of naturally occurring biodegrading activity in the groundwater plume. Specific requirements regarding the evaluation of groundwater data are presented in Section 5. Based on the data presented in the Remedial Action Report, the Agencies will determine whether to (1) extend the performance period, (2) move Zone 1 into long-term operations and continue the performance period for Zone 2, or (3) end the performance period for Zone 1 and Zone 2 and move into the long-term operations phase. Depending on which option is supported by the data, a second Remedial Action Report could be produced after the Zone 2 performance operations phase to document performance in Zone 2.

Data collected during the first 2 years of performance operations will be used to calibrate and, if necessary, revise the numerical fate and transport model. The calibrated numerical model will be used during performance operations to predict long-term concentration trends and determine whether RAOs can be achieved by 2095. Specific requirements for the model update activity are provided in Section 5.

2.3.2 Long-Term Operations Phase

Long-term operations will begin for each zone once the determination is made that MNA is operational and functional in that zone. This phase will consist of periodic groundwater monitoring for the duration of the remedial action period to track the remedy's progress toward achieving the RAOs. The Agencies will determine the monitoring frequency for long-term operations, as based on the Remedial Action Report. Once long-term operations begin, MNA will be considered functional and operational, and, as any other CERCLA remedy, it will be reviewed at least every 5 years to verify performance.

Monitoring will continue in Zone 3 throughout both operational phases. In the Record of Decision Amendment (DOE-ID 2001a), it was determined that acceptable plume expansion is limited to 30%, based on the understanding of plume length in the Explanation of Significant Differences (INEEL 1997). The 30% expansion will be determined based on the extent to which the length of the plume along the major axis increases.

Figure 2-2 illustrates the sequence for performance operations and long-term operations. The requirements for the data evaluation activities are developed in Section 5. The groundwater-monitoring requirements for each zone and operational phase are developed in Section 7. Table 2-2 provides a summary of the performance monitoring/compliance monitoring requirements.

2.4 Integration of Remedial Action Components

As described in Section 1 of this document, each of the three remedial components (ISB, NPTF, and MNA) is integral to the overall remedy's success. The selected remedial strategy for the TCE plume's distal zone is MNA. Monitored natural attenuation does not directly address contamination in the hot spot and medial zone, but assumes that the other remedy components will meet their performance goals. The MNA component is implemented in conjunction with the more active remedial strategies of ISB and the NPTF that physically modify, remove, or treat the contaminant in the secondary source term or in the groundwater.

Each of the three remedial components has distinct requirements to monitor the success of that component. Table 2-3 provides a crosswalk between the three remedial components and the respective groundwater-monitoring requirements.

After ISB and NPTF operations are complete, natural attenuation will continue to lower residual contamination levels in the hot spot and medial zone. Figure 2-3 is a generalized remedy sequence that illustrates the incorporation of the medial zone and hot spot into MNA activities as TCE concentrations decrease with time. Figure 2-3 also illustrates the interaction of the monitoring programs associated with each component over the remedy's life.

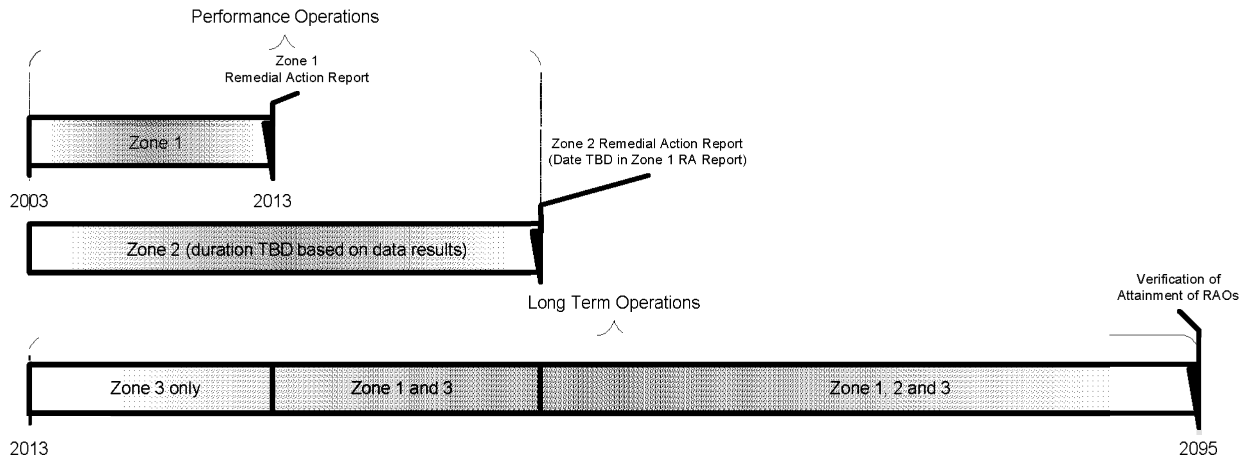


Figure 2-2. Summary illustration of the remedial action operational phases for monitored natural attenuation.

Table 2-2. Summary of performance and compliance monitoring requirements for monitored natural attenuation.

Performance Monitoring/Compliance Monitoring Summary					
Operations Phase	Monitoring Zone[a]	Performance Monitoring Requirements[b]	Compliance Monitoring Requirements[b]	Completion Criteria[c]	Key Deliverables[d]
Performance operations	1	Annual monitoring for MNA performance parameters and upgradient radionuclides in accordance with the requirements of Table 2-3.	Annual VOC and radiological monitoring per Remedial Action Work Plan	Zone 1 will be operational and functional when (1) peak TCE breakthrough is exhibited in data before the numerical model-bounding estimate and (2) radiological data indicate attenuation sufficient to meet RAOs.	Model Verification Report Zone 1 Remedial Action Report
	2	Annual monitoring for MNA performance parameters in accordance with the requirements of Table 2-3.	Annual VOC monitoring per Remedial Action Work Plan	Zone 1 will be operational and functional when peak TCE breakthrough is exhibited in data before the numerical model-bounding estimate. Alternatively, the Agencies may determine Zone 2 to be operational and functional when (1) Zone 1 performance operations are complete and (2) a biodegradation mechanism has been demonstrated.	Zone 2 Remedial Action Report
Long-term operations	1	Monitoring frequency will be determined in the Remedial Action Report.	Monitoring frequency TBD in Remedial Action Report	Monitoring data verify that RAOs have been attained.	Operations, Maintenance, and Monitoring Report
	2	Monitoring frequency will be determined in the Remedial Action Report.	Monitoring frequency TBD in Remedial Action Report		
	3	Volatile organic compound monitoring will be performed once every 3 years. (If TCE in GIN-04 >10 µg/L, sampling will be increased to annual; if TCE in TAN-56 >10 µg/L, a new well will be installed at the 30% down gradient location.)	VOC monitoring once every 3 years per Remedial Action Work Plan		

a. Zone 1 wells are TAN-16, TAN-25, TAN-28, TAN-29, TAN-30A, TAN-37, TAN-51, TAN-54, TAN-55, and TSF-05. Zone 2 wells are TAN-21, TAN-52, and ANP-8. Zone 3 wells are GIN-4, TAN-56, TAN-57, and TAN-58.
b. Detailed monitoring requirements for each zone and phase were developed in accordance with the requirements of the *Data Quality Objectives Process for Hazardous Waste Site Investigations* (EPA 2000a) and are detailed in Section 7.1.
c. Decision rules for each zone and phase were developed in accordance with the requirements of the *Data Quality Objectives Process for Hazardous Waste Site Investigations* (EPA 2000a) and are detailed in Section 7.4.
d. Deliverables and schedules are described in Sections 7.7 and 13, respectively.
EPA = U.S. Environmental Protection Agency
MNA = monitored natural attenuation
RAO = remedial action objective
TAN = Test Area North
TCE = trichloroethene
TSF = Technical Support Facility
VOC = volatile organic compound

Table 2-3. Monitoring crosswalk table for the Operable Unit 1-07B groundwater-remediation remedy.

Monitoring Zone	Monitoring Type	Sample Parameter	Decision/Evaluation Objective	Goal	Sample Program	Basis Document
Hot spot	ISB performance	ISB performance parameters: VOCs Tritium Ethene, ethane, methane, redox, electron donor, bioactivity, and nutrient	Trending Donor distribution Source degradation Flux New donor	Optimize operation to meet compliance objectives/requirements.	ISB	ISB Work Plan
	ISB compliance	VOCs (TAN-28 and TAN-30A)	VOCs below MCLs for 1 year	Achieve reduction of down-gradient flux to below MCLs.	ISB	ISB Work Plan
		VOCs (PMW-1 and PMW-2)	VOCs below MCLs for 1 year	Achieve reduction of cross-gradient flux to below MCLs.		
	ISB completion compliance	All VOCs (wells TBD)	Hot spot completion	Determine whether ISB RAOs have been met in the hot spot.	ISB	ISB Remedial Action Report
	NPTF performance	VOCs plus radionuclides (strontium, cesium) (wells TBD)	Upgradient source	NPTF contingency evaluation monitoring	NPTF	NPTF Work Plan
	MNA performance	Radionuclides (strontium and cesium; TAN-25, TAN-37, TAN-28, TAN-30A, TAN-29, and TSF-05)	Upgradient radionuclide monitoring (hot spot)	Monitor/evaluate hot spot radionuclide degradation and migration.	MNA	MNA Work Plan
Medial zone	NPTF performance	Draw down	Facility operations	Plume capture	NPTF	NPTF Work Plan
	NPTF compliance	Facility influent/effluent VOCs and strontium	Facility operations	Stay within influent and effluent specifications.	NPTF	NPTF Work Plan
	NPTF completion compliance	Air emissions	Facility operations	Stay within effluent specifications.		
		Operations uptime	Facility operations	Maintain 90% uptime.		
		Extraction flow rate	Facility operations	Operate within specified flow rate.		NPTF Work Plan
		All COCs (wells TBD)	Medial zone completion	Determine that NPTF RAOs have been or can be met in the medial zone.	NPTF	

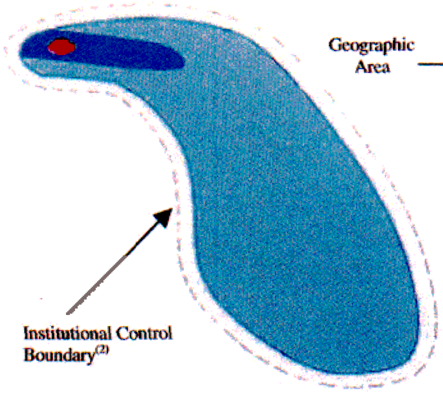
Table 2-3. (continued.)

Monitoring Zone	Monitoring Type	Sample Parameter	Decision/Evaluation Objective	Goal	Sample Program	Basis Document
Distal zone	MNA performance	MNA performance parameters: TCE DCE PCE VC Tritium	Breakthrough curves	Trends are toward achievement of RAOs.	MNA	MNA Work Plan
	MNA compliance	MNA performance parameters for 5 years	Plume expansion			
			Degradation rate	Annual sampling is a requirement for at least the first 5 years.	MNA	MNA Work Plan
	MNA completion compliance	All COCs	MNA performance parameters	Determine that RAOs have been met throughout the plume.	MNA	MNA Remedial Action Report
			Remedial action completion			

COC = contaminant of concern
DCE = dichloroethene
ISB = in situ bioremediation
MCL = maximum contaminant level
MNA = monitored natural attenuation
NPTF = New Pump and Treat Facility
PCE = tetrachloroethene
RAO = remedial action objective
TAN = Test Area North
TBD = to be determined
TCE = trichloroethene
VC = vinyl chloride
VOC = volatile organic compound

2001–2015[1]

Operations during this period consist of ISB at the hot spot, NPTF at the medial zone, and MNA in the distal zone. It is assumed that ISB has successfully achieved the completion criteria for performance operations, which consist of stopping VOC flux from the hot spot.



Monitoring Program

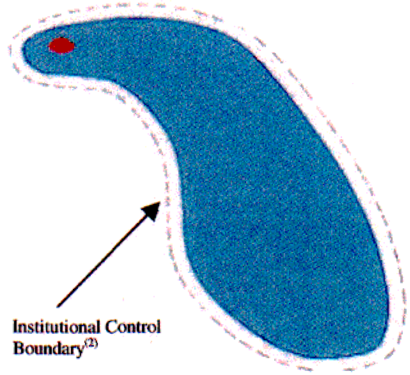
Hot Spot	Medial Zone	Distal Zone	Remedy Component
ISB Performance ISB Compliance			ISB
NPTF Performance (NPTF Contingency)	NPTF Performance NPTF Compliance		NPTF
MNA[3] Performance (Radionuclide)	N/A	MNA[3] Performance	MNA

2016–2020[1]

Operations during this period consist of ISB at the hot spot and MNA for the distal zone[4]. It is assumed that the NPTF has successfully achieved the medial zone completion criteria and is in standby mode.

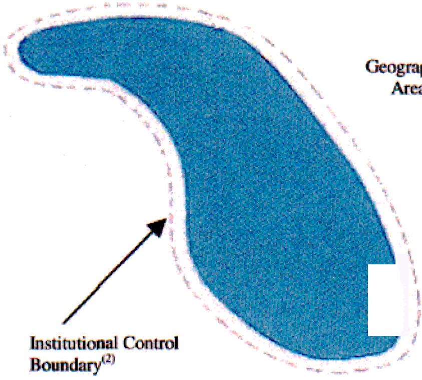
Monitoring Program

Hot Spot	Medial Zone	Distal Zone	Remedy Component
ISB Performance ISB Compliance			ISB
N/A	N/A		NPTF
MNA Performance (Radionuclide)	MNA Performance[5]	MNA Performance	MNA



2021–2095[1][6]

Operations during this period consist of MNA in the distal zone[4]. It is assumed for this period that ISB has successfully achieved the completion criteria for long-term operations and not only has the flux been cut off, but the source has been degraded



Monitoring Program

Hot Spot[7]	Medial Zone	Distal Zone	Remedy Component
			ISB
			NPTF
MNA Performance[5] (Radionuclide)	MNA Performance[5]	MNA Performance	MNA

(1) The dates and the shape of the plume shown are for illustrative purposes only.
(2) The institutional control boundary extends 40% beyond the current dimensions of the plume; expansion accounts for 30% and a buffer zone accounts for 10%.
(3) The MNA compliance requirements during this period consist of annual monitoring for at least the first 5 years.
(4) The distal zone is defined as the areal extent of the plume that is less than 1,000 µg/L TCE and greater than 5 µg/L TCE.
(5) The MNA monitoring program will be expanded to include additional wells to be monitored for MNA performance parameters.
(6) Assumes the hot spot has been removed.
(7) In situ bioremediation or some yet-to-be-determined technology will operate at the hot spot until hot spot RAOs are achieved.

Figure 2-3. Generalized-monitoring program operations throughout the remedy timeframe.

3. STATUTORY DETERMINATIONS AND COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Under Section 121(d) of CERCLA (42 USC § 9601 et seq.) and the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300.430[f][1][I][B]), the Agencies must select remedies that protect human health and the environment, comply with ARARs, are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ, as a principal element, a treatment that permanently and significantly reduces the toxicity, mobility, or volume of hazardous waste and has a bias against off-Site disposal of untreated waste. Section 9 of the Record of Decision Amendment (DOE-ID 2001a) discusses how MNA meets these statutory requirements.

Implementation of the remedy will comply with all specified ARARs. Table 3-1 lists the ARARs that are applicable to the MNA remedial component. The threshold criteria for MNA include (1) overall protection of human health and the environment and (2) compliance with ARARs.

3.1 Overall Protection of Human Health and the Environment

The MNA remedy will be protective of human health and environment by eliminating, reducing, and controlling the risks posed by the site through treatment of groundwater contaminants. The distal zone remedy will monitor naturally occurring TCE degradation to ensure that RAOs are achieved within remedial timeframes.

3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Appendix B, Table B-1 describes how the MNA system will comply with the regulatory requirements.

Table 3-1. Summary of applicable or relevant and appropriate requirements for the monitored natural attenuation remedy.

Requirement (Citation)	ARAR Type Action-Specific	 Chemical-Specific	 Location-Specific	Requirement Type	Comments
RCRA and Hazardous Waste Management Act					
Generator Standards (IDAPA 58.01.05.006) "Hazardous Waste Determination" (40 CFR 262.11)	X	—	—	A	Not required for secondary waste streams in the medial and distal zones, for which applicable no-longer-contained-in determinations have been made.
General Facility Standards (IDAPA 58.01.05.008)	—	—	—	—	—
"General Waste Analysis" (40 CFR 264.13)	—	—	X	A	—
"Preparedness and Prevention" (40 CFR 264, Subpart C; 40 CFR 264.31-.37)	X	—	—	A	—
"Use and Management of Containers" (40 CFR 264, Subpart I)	X	—	—	A	—
"Land Disposal Restrictions" (IDAPA 58.01.05.011)	X	—	—	A	—
RCRA, Section 3020	X	X	—	A	—
Underground Injection Control					
"Rules and Minimum Standards for the Construction and Use of Injection Wells in the State of Idaho" (IDAPA 37.03.03)	X	X	—	A	—
Idaho Public Drinking Water					
MCLs (numerical standards only) (IDAPA 58.01.08.050.02 and .05)	—	X	—	R	—
National Historic Preservation Act					
Scope of Identification (36 CFR 800.4[a][1][i], [iii][a][2])	—	—	X	A	—
Identify Historic Properties (36 CFR 800.4[b])	—	—	X	A	—

Key:
A = applicable requirement
R = relevant and appropriate requirement
CFR = *Code of Federal Regulations*
IDAPA = Idaho Administrative Procedures Act
MCL = maximum contaminant level
RCRA = Resource Conservation and Recovery Act

4. TECHNICAL BASIS FOR SELECTION OF MONITORED NATURAL ATTENUATION

The original Record of Decision (DOE-ID 1995) provided the option to modify the remedy with the Agencies' approval, if modifications provided more effective cleanup of the aquifer. The Record of Decision required treatability studies to be conducted that focused on specific technologies offering the potential to be more cost effective than the original pump-and-treat remedy. Subsequent treatability studies provided evidence that MNA would be an effective component of the remedy. The technical basis for selection of MNA by the Agencies was initially documented in the Field Demonstration Report (DOE-ID 2000).

The Field Demonstration Report implemented EPA guidance (EPA 1999) for evaluating and selecting MNA as a remedy or a component of a remedy. The guidance established specific criteria for selecting MNA, including thorough site-specific characterization data and a detailed understanding of the nature and rate of natural attenuation processes at the site. Because these criteria also provide the basis for the monitoring program's design, they are discussed in detail in this section. This section summarizes the results of the Field Demonstration Report and includes data that are more recent and analysis in support of MNA. The section concludes with a discussion of the important monitoring parameters for MNA.

4.1 Geohydrologic Conditions Influencing Monitored Natural Attenuation Performance at Test Area North

The technical basis for MNA is contingent upon an understanding of the geohydrologic conditions at TAN, which include an understanding of those conditions that control flow and contaminant transport, the source of contaminants, and the distribution and migration of contaminants in the Snake River Plain Aquifer (SRPA) at TAN. The following subsections describe the geohydrologic setting for the distal zone of the contaminant plume and contaminant disposal history, contaminant source composition, and the distribution of contaminants in the groundwater.

4.1.1 Geohydrologic Setting

The geohydrologic setting controls the distribution and transport of contaminants in the SRPA. The hydrologic setting includes the geologic framework of the aquifer, distribution of hydraulic properties that control the storage and transmission of groundwater, inflows and outflows, and the configuration of the resultant field of flow.

4.1.1.1 Geologic Framework. Surficial sediments at TAN consist largely of lacustrine sediments deposited in ancient Lake Terreton and playa sediments deposited in the Birch Creek Playa. The lacustrine deposits are sandy and clayey silt with lesser amounts of clay, silt, and fine gravel. These deposits include sandy beach and bar sediments that were derived from the Big Lost River and Birch Creek. The playa deposits consist of poorly sorted sand, silt, and clay and were derived from reworked Terreton Lake sediments. The lacustrine and playa sediments at TAN were deposited during the last 900,000 years of eruptive quiescence and range in thickness from 1.5 to 23 m (5 to 75 ft).

A thick sequence of quaternary basalt flows underlies the surficial sediments. The basalt stratigraphy at TAN consists of thin pahoehoe basalt flows that erupted from volcanic vents. These basalt flows are intercalated with sedimentary interbeds that accumulated during periods of eruptive quiescence.

The United States Geological Survey (USGS) conducted two studies of the stratigraphy at TAN. Twenty-one individual basalt flows in four coreholes were identified in the *Petrography, Age, and*

Paleomagnetism of Basaltic Lava Flows in Coreholes at Test Area North (TAN), Idaho National Engineering Laboratory (Lanphere, Kuntz, and Champion 1994) to a depth of 335 m (1,100 ft) at TAN using petrography, age determinations, and paleomagnetic properties of the core samples for correlation. This study also used K-Ar and paleomagnetic analyses of core samples and basalt outcrop at Circular Butte to delineate 21 subsurface basalt flows at TAN.

Anderson and Bowers (1995) used core data from the Petrography, Age, and Paleomagnetism of Basaltic Lava Flows in Coreholes at Test Area North report (Lanphere, Kuntz, and Champion 1994) and natural gamma logs to correlate basalt stratigraphy in 53 additional holes at TAN. A cross-sectional diagram from this work is presented in Figure 4-1. The natural gamma logs are sensitive to the small differences in potassium content and natural gamma emissions of basalt flows from different source areas or eruptive episodes. Twenty-two individual basalt flows were identified in the upper 152 m (500 ft) of the subsurface at TAN. In addition, several sedimentary interbeds were identified. In total, basalt flows account for 90% and sedimentary interbeds account for 10% of the upper 152 m (500 ft) of the subsurface at TAN. The individual basalt flows were assigned to 10 groups based on similar age, paleomagnetic properties, and natural gamma emissions. These groups, assigned alphabetic designations beginning with LM and continuing through R and based on age and position, typically are older than basalt flow groups in the central and southern parts of the INEEL and are characterized by chemical alteration. Five to 10 sedimentary units are interbedded with the basalt flow groups. Two of these were identified as major interbeds, designated as the PQ and QR interbeds, based on their position in the basalt flow group's stack.

The PQ interbed occurs at approximately 61 m (200 ft) below land surface (bls) near TSF-05 and occurs in only 36 of the 60 wells that penetrate to a depth where the interbed might be expected (Sorenson 2000). The average thickness of the PQ interbed in wells where it is penetrated is 1.9 m (6.1 ft). The PQ interbed occurs at or above the water table north of TAN and dips below the water table to the south and east. This interbed may confine flow locally in the aquifer and may restrict vertical contaminant migration and provide contaminant sorption sites.

The QR interbed occurs at approximately 122 m (400 ft) bls near the TSF-05 injection well. The QR interbed apparently is laterally continuous because the interbed is present in all 29 wells that penetrate to a depth where it may be expected (Sorenson 2000). The average thickness of the QR interbed in wells is 5.2 m (17 ft). Lanphere, Kuntz, and Champion (1994) used K-Ar dating to estimate a difference in age of approximately 600,000 years between the Q and R basalt flow groups straddling the QR interbed. These measurements indicate a significant cessation of volcanic activity during which sediments comprising the interbed were extensively deposited. The TCE concentrations below the QR interbed are several orders of magnitude smaller than concentrations above the interbed. Furthermore, water levels in TAN-18, which is completed below the interbed, show no response to pumping in nearby wells completed above the interbed. These data strongly indicate that the interbed restricts vertical groundwater flow and associated contaminant transport and serves as the effective base of contamination in the TAN aquifer.

Test Area North is located between two volcanic rift zones that cross the eastern Snake River Plain. The Circular Butte–Kettle Butte Rift Zone lies to the north of TAN, and the Lava Ridge–Hell's Half Acre Rift Zone lies to the southwest. The proximity of TAN to the Lava Ridge–Hell's Half Acre Rift Zone locally might affect the distribution of hydraulic properties and the transport of contaminants.

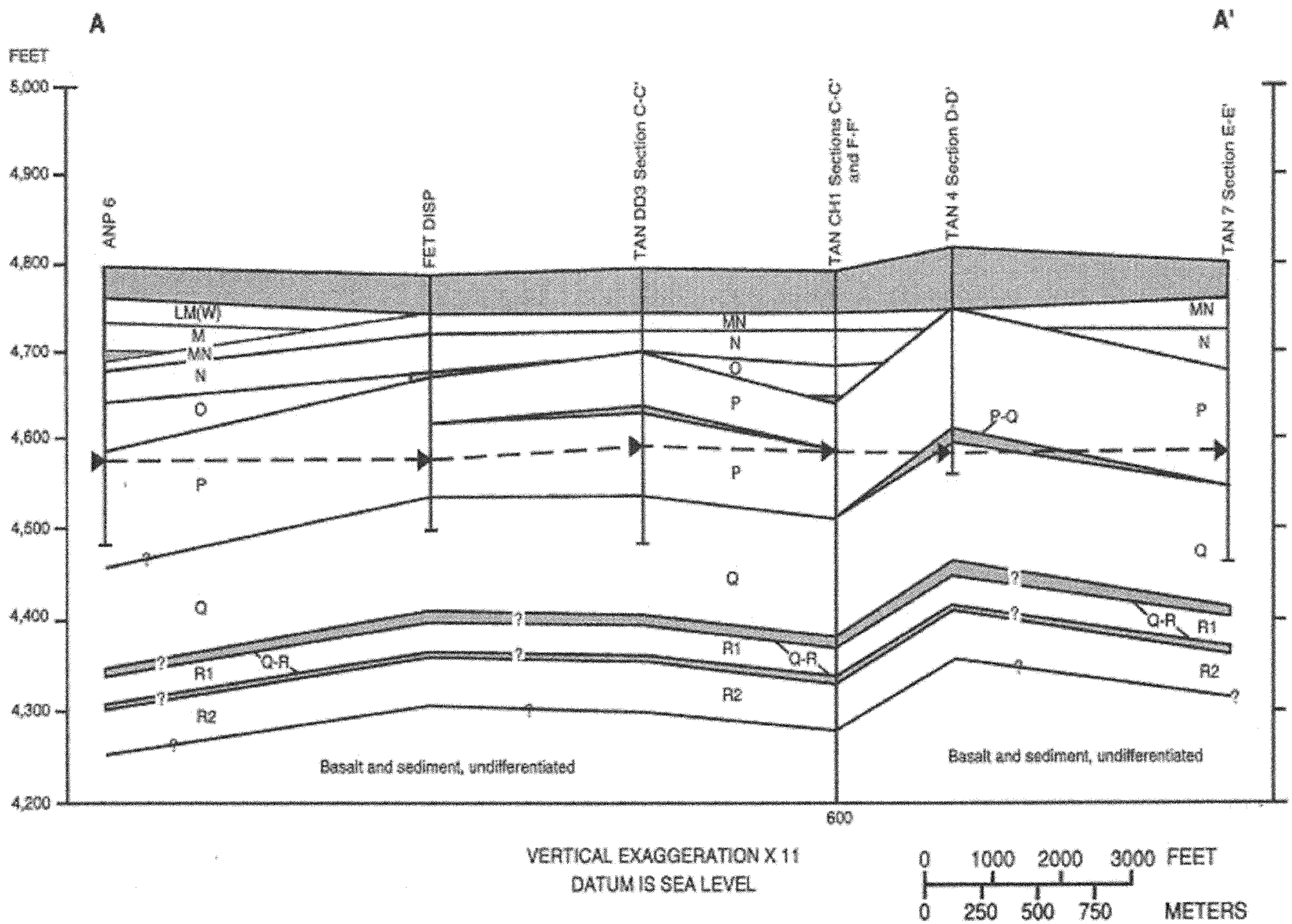


Figure 4-1. Stratigraphy of the Waste Area Group 1 site (Anderson and Bowers 1995).

4.1.1.2 Distribution of Hydraulic Properties. The vadose zone at TAN is approximately 61 to 70 m (200 to 230 ft) thick. The SRPA at TAN is estimated to be about 183 m (600 ft) thick, although the upper 61 to 91 m (200 to 300 ft) appears to be isolated hydraulically from deeper zones by the QR sedimentary interbed. Water-chemistry and pumpage data indicate that the QR interbed serves as the base to the overlying basalts, effectively limiting the contaminated thickness of the aquifer to approximately 61 m (200 ft) near TSF-05 and about 76 m (250 ft) near the down-gradient extent of the TCE plume.

The capability of the SRPA at TAN to transmit water has been estimated by different researchers using different analytical methods. Ackerman (1991) used aquifer test data from nine wells near TAN to estimate transmissivity, the largest of which was 2,880 m^2/day (31,000 ft^2/day). This analysis indicated that transmissivity at TAN generally was less than the average for the entire INEEL (8,640 m^2/day [93,000 ft^2/day]). The transmissivity from slug tests was estimated to range from 0.46 to 679 m^2/day (5 to 7,310 ft^2/day) (Kaminsky et al. 1994). These estimates were smaller than Ackerman's estimates, perhaps because the slug tests sampled a smaller volume of the aquifer. Sorenson (2000) estimated a range of transmissivity from 163 to 648 m^2/day (1,755 to 6,975 ft^2/day) using specific-capacity data from wells. Other single- and multiple-well aquifer tests near TAN were used to estimate transmissivity from 92.9 to 46,450 m^2/day (1,000 to 500,000 ft^2/day). The general distribution of transmissivity values ranging from 0.46 to 2,880 m^2/day (5 to 31,000 ft^2/day), considered to be typically smaller than those for other areas on the INEEL, might be attributed to the reduced permeability of the older, chemically altered basalts present at TAN.

The wide range of transmissivity values of the SRPA at TAN is attributed to heterogeneities associated with the complex stratigraphic relations and the distribution, frequency, and interconnection of fractures in basalt. The smaller transmissivity values indicated south of TAN might be attributable to buried volcanic features in proximity to an inferred vent corridor.

The effective porosity of the SRPA basalts and interbeds at TAN is the ratio of the volume of interconnected pore spaces available to store water to the total rock volume. The effective porosity of the aquifer at the scale of the TAN TCE plume has been estimated using inverse modeling techniques to be about 3% (INEEL 1999b). This value is half that observed in a similar, large-scale characterization effort at the INEEL (DOE-ID 1997). This small, effective porosity might be attributed to chemical alteration and partially filled pore volumes of older basalts that make up the SRPA at TAN.

4.1.1.3 Inflows and Outflows. Groundwater inflow to the SRPA at TAN occurs from regional underflow from the north and northeast. Regional underflow is derived primarily from the Mud Lake area to the northeast. Additional minor underflow contributions may be derived from tributary basin underflow along the flanks of the Beaverhead Mountains and from groundwater underflow and surface-water recharge from the Birch Creek drainage; however, underflow from these sources is not well understood. Locally, infiltration of direct precipitation provides another minor source of recharge to the SRPA.

Outflow from TAN occurs as regional underflow to the south. Groundwater pumpage from TAN production wells comprises a small component of SRPA outflow.

4.1.1.4 Groundwater Flow Direction, Gradient, and Velocity. The direction of groundwater flow near the TAN TCE plume locally is to the east and to the southeast, in contrast to the subregional flow direction to the south and southwest. This local flow direction is reflected by the east and southeast orientation of the plume. The local change in flow direction might be attributed, in part, to an area south of TAN that is characterized by reduced hydraulic conductivity, as discussed in the Test Area North Site Conceptual Model and Proposed Hydrogeologic Studies Operable Unit 1-07B (INEEL 1996) and Waste Certification Plan for the Environmental Restoration Program (Jones 1997). This area lies in proximity to inferred rift-zone features. The direction of groundwater flow and transport in the contamination plume's distal part in the aquifer near TSF-05 also may be affected locally by (1) recharge from the TSF-07 disposal pond, (2) pumping at the TAN production wells, and (3) the regional southerly gradient. The hydraulic gradient at TAN is approximately 0.0002 m/m to the east-southeast (Kaminsky et al. 1994; INEEL 1999a).

Borehole geophysical measurements of hydraulic properties and measurements of contaminant distribution with depth at TAN indicate that horizontal flow occurs preferentially in the basalts and is associated with the complex distribution of interflow and fracture zones. Vertical heterogeneities not only control flow, but they also control the vertical distribution of contaminants throughout the contaminated thickness of the aquifer.

The groundwater velocity throughout the plume probably is best estimated using the numerical model calibration for tritium transport. The average estimated groundwater velocity is about 0.15 m/day (0.49 ft/day) for most of the plume. This is consistent with an estimate of 0.13 m/day (0.43 ft/day) (Kaminsky et al. 1994), which is based on evidence for the travel time from TSF-05 to USGS-24 during operation of the injection well. However, the model estimates a slower groundwater velocity of 0.073 m/day (0.24 ft/day) in the plume's upgradient portion, which is located near the source area.

4.1.1.5 Summary of Important Hydrologic Concepts. The following list summarizes the hydrologic setting for the TAN plume's distal zone:

1. The effective thickness of the SRPA in the TAN TCE plume's distal zone is approximately 61 to 76 m (200 to 250 ft) thick. This part of the aquifer overlies a sedimentary interbed that effectively restricts vertical contaminant migration.

2. Transmissivity estimates for the SRPA at TAN typically are smaller than the range of estimates for the entire INEEL. Transmissivity values vary over as much as five orders of magnitude in wells at TAN and range from 0.46 to 2,880 m^2/day (5 to 31,000 ft^2/day).

3. The direction of groundwater flow and transport in the contaminated aquifer's distal zone near TSF-05 is to the east and southeast.

4. The average groundwater velocity in the distal zone is estimated from numerical modeling results to be 0.15 m/day (0.49 ft/day).

5. The effective porosity in the TCE plume's distal zone is estimated from numerical modeling results to be 3%, which is approximately half that estimated for other parts of the SRPA.

4.1.2 Contaminant Sources in Groundwater in the Trichloroethene Plume's Distal Zone

Liquid waste and sludge were injected into Well TSF-05 at TAN for nearly 20 years; the injection ended in 1972. The injection interval in Well TSF-05 consisted of the upper 30 m (100 ft) of the SRPA. Because of this injection history, a significant quantity of residual contaminant material remains in the basalt and sediment beneath the water table near TSF-05. This residual material is commonly referred to as the "secondary source." Waste injection and subsequent leaching from the secondary source have resulted in a contaminant plume that extends approximately 3.22 km (2 mi) to the east and southeast of the TSF-05 injection well (see Figure 2-1).

During the early groundwater characterization activities at TAN, sludge filled the bottom 16.8 m (55 ft) of the TSF-05 well casing (Kaminsky et al. 1994). Sludge was removed from the well in 1990. The analytical results of the sludge for the constituents of greatest interest to this work are summarized in

Table 4-1. The TCE was measured at 30,000 mg/kg or 3% by weight. While tetrachloroethene (PCE) and dichloroethene (DCE) concentrations were smaller than TCE concentrations, they were still significant contaminants.

Table 4-1. Contaminant concentrations in TSF-05 sludge from 1990 (Kaminsky et al. 1994).

Contaminant	Concentration
TCE	30,000 mg/kg
PCE	2,800 mg/kg
1,2-DCE	410 mg/kg
Co-60	812 pCi/g
Cs-137	2,340 pCi/g
Tritium	1.03×10^6 pCi/L
Gross Beta	118,800 pCi/L

DCE = dichloroethene
PCE = tetrachloroethene
TCE = trichloroethene
TSF = Technical Support Facility

High tritium concentrations remained in the sludge in basalts near Well TSF-05, almost 20 years after use of the injection well ceased. Because tritium is present as part of the water molecule, it is most likely to be transported conservatively through groundwater flow. However, in wells away from TSF-05, tritium concentrations have never exceeded the 20,000-pCi/L drinking water standard, despite the fact that concentrations in the sludge are 1.5 orders of magnitude higher. These high concentrations indicate that the tritium has not migrated extensively from the secondary source. The sludge apparently has reduced advective flow, permitting only small amounts of tritium to diffuse from the secondary source for down-gradient transport.

Other radioactive contaminants that remain in the sludge are subject to sorption within the sludge, thereby further restricting their migration. Two gamma emitters, Co-60 and Cs-137, were both present in the sludge at significant activity levels. Their presence was useful as a sludge distribution tracer. Observed Co-60 and Cs-137 activity extended as far as Well TAN-D2, which is located about 35 m (115 ft) northwest of TSF-05. Logging of TAN-37, 40 m (130 ft) east of TSF-05, did not show elevated gamma activity. The vertical profiles of elevated gamma activity also correlated among the wells and with high-permeability zones identified through seismic tomography (INEEL 1998). These profiles further indicated that the layered basalt flows provided preferential subhorizontal flow paths for the sludge away from the injection well. The profiles also indicated that elevated gamma activity was only present to about 91 m (300 ft) bls, which is approximately the bottom of the TSF-05 injection interval. Therefore, the residual source appears to exist primarily in the upper 30 m (100 ft) of the aquifer and within a radius of less than 40 m (130 ft) from Well TSF-05.

The gross beta activity of 118,800 pCi/L in the sludge is attributed primarily to strontium-90. Strontium-90 concentrations in water from wells close to Well TSF-05 typically exceed 500 pCi/L. Concentrations decrease to less than the 8-pCi/L MCL a short distance from TSF-05. Figure 4-2 is a plot showing strontium-90 activities with distance downgradient from the TSF-05 injection well. This plot shows that strontium-90 activities decrease approximately 1.5 orders of magnitude within a downgradient distance of 150 m (500 ft). This decrease is attributed to sorption, dispersion, and radioactive decay. Strontium-90 activities are less than the 8-pCi/L MCL in water from wells at distances more than 150 m (500 ft) downgradient from the injection well.

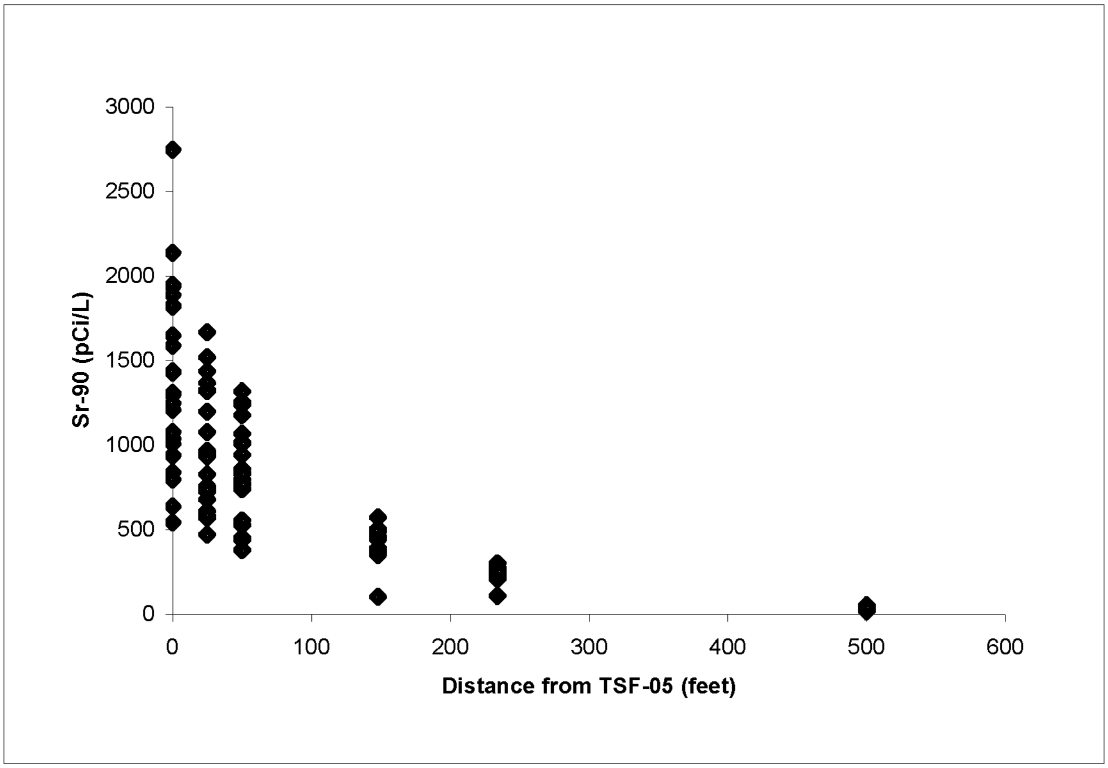


Figure 4-2. Strontium-90 activities decline with distance from TSF-05.

The spatial extent of the sludge, which comprises the secondary source of contamination, was estimated based on differences in the hydrologic properties of the aquifer near TSF-05. A numerical model of the TSF-05 area was developed through inverse modeling of multiple well-pumping tests (INEEL 1998). The effective porosity within about 20 m (66 ft) of TSF-05 was calibrated to range between less than 0.05 and 0.1%. The effective porosity in the bulk of the model domain was closer to 1%. The large reduction of effective porosity around TSF-05 probably can be attributed to clogging of the formation by sludge (residual source material).

Finally, as part of the bioremediation field evaluation, a diverging tracer test was performed (using TSF-05 as the injection point) that provided data useful for estimating the extent of the aquifer with reduced effective porosity due to the sludge. Two models were applied to the data to estimate effective porosity near TSF-05. Both models revealed very low effective porosities ranging from 0.04 to 0.1% within 15 m (50 ft) of TSF-05 and increasing porosities with distance (Sorenson 2000). These results are consistent with significant plugging of the formation with sludge near TSF-05 that decreases with distance from the well. A "bull's-eye model" was developed to estimate the distance from TSF-05 at which the porosity transition occurs and, hence, the radial extent of the sludge. Based on that simple model, the sludge extent was estimated to reach about 29 to 30 m (95 to 100 ft) from TSF-05 (Sorenson 2000).

Slow diffusion of contaminants from the secondary source at TSF-05 has sustained downgradient contaminant concentrations in groundwater long after cessation of waste disposal to the injection well. Active remediation of the hot spot through ISB and of the medial zone through the NPTF will affect upgradient secondary-source contributions of VOCs and radioactive constituents to the distal zone. Understanding of long-term contaminant contributions from the secondary source is essential for achievement of RAOs through MNA.

4.2 Evaluation of Natural Biodegradation Mechanisms and Degradation Rates

Initially, natural attenuation processes in the TCE plume were believed to be controlled by anaerobic reductive dechlorination and dispersion. However, groundwater chemical data provided indirect evidence that another mechanism was operating in the TCE plume's distal zone. Analyses showed that dissolved oxygen was depleted in groundwater only near TSF-05. This depletion probably occurred in response to degradation of sanitary sewage and organic compounds co-disposed of with TCE. Downgradient, dissolved oxygen rapidly increased, indicating the presence of aerobic conditions throughout most of the plume. Based on this information, anaerobic reductive dechlorination was determined to be operational only in the anaerobic part of the plume near TSF-05. If no natural attenuation was taking place in the distal zone, TCE concentrations would be expected to increase with time downgradient from the contaminant source at TSF-05, because the aquifer is constrained vertically by the QR interbed and because TCE and other VOC concentrations within the secondary source have remained high over the 30 years since waste injection was terminated. In addition, areas of high concentrations would be expected to expand. However, based on 10 years of data, concentrations of TCE downgradient from TSF-05 showed little or no increase. In addition, plume expansion was minimal. These observations suggested that a mechanism for natural attenuation was operational within the plume's aerobic distal zone.

The evaluation of natural biodegradation mechanisms and degradation rates was defined through a sequence of regulatory activities and documents and a series of technical studies. Subsequent sections present the chronology of regulatory activities and a discussion of natural degradation studies that provided a technical basis for implementing MNA at TAN.

4.2.1 Estimation of a Degradation Rate for Monitored Natural Attenuation and Implications for Remedial Action Objectives

In the Record of Decision Amendment (DOE-ID 2001a), the Agencies agreed that a 10- to 20-year degradation half-life for TCE would achieve RAOs within the remedial timeframe. Data available at that time indicated that observed degradation rates were within that range. During development of this Remedial Action Work Plan, a substantial new set of monitoring data was available to support a final refinement of the rate estimate. The following analysis establishes a defensible estimate of the TCE degradation rate that is occurring naturally as the result of biologically mediated processes. The establishment of a degradation rate also supports the evaluation of MNA's effectiveness during the remedy's performance-monitoring phase.

The TCE concentrations were compared to concentrations of tritium and PCE using a technique referred to as the tracer-corrected method (Sorenson et al. 2000; DOE-ID 2000). This technique allowed researchers to evaluate the potential for volatization, sorption, and dispersion and to determine whether any unique degradation processes were affecting TCE in the distal zone. By comparing ratios of TCE to tracers, it was demonstrated that TCE concentrations decreased relative to both corrected tritium and PCE concentrations. This decrease strongly suggested the operation of an aerobic degradation mechanism.

Numerical modeling exercises further supported this indirect evidence. A three-dimensional petroleum-engineering/geothermal-simulator model (i.e., TETRAD), calibrated to tritium concentrations in groundwater, was used to evaluate TCE concentrations in two cases (DOE-ID 2000). The first case assumed no degradation of TCE. The second case assumed that degradation was taking place with a TCE half-life of 11 years, based on the initial tracer-corrected method estimates. Both cases adequately simulated the known extent of TCE in groundwater. However, the distribution of concentrations within the simulated plume differed greatly. In the first case with no degradation, predicted TCE concentrations were significantly higher than observed concentrations in the hot spot and medial zone. With degradation, the three-dimensional distribution of predicted concentrations was similar to the distribution of observed concentrations.

Although TCE concentration trends indicated that attenuation was occurring, they did not indicate the mechanism for that attenuation. Subsequent studies identified aerobic co-metabolism of TCE as a potential mechanism for the apparent degradation of the TAN TCE plume. Co-metabolism is the degradation of compounds by microbial enzymes without benefit to the organism. The capability of TCE co-metabolism has been documented for bacteria grown on substrates such as methane (Wilson and Wilson 1985), propane (Fliermans et al. 1988), phenol (Folsom, Chapman, and Pritchard 1990), toluene (Nelson et al. 1986), butane (Wilson, Pogue, and Canter 1988), ammonia (Arciero et al. 1989), and others. In many of the co-metabolic pathways using any of these substrates, an oxygenase enzyme acts on the chlorinated ethenes (TCE, DCE, or vinyl chloride [VC]) and aids in degrading the contaminant. The TCE is not a food source for the microorganisms, but it is transformed by microbial enzymes (i.e., monooxygenase) that catalyze oxidation of other organic substrates.

In addition to a thorough evaluation of contaminant data, laboratory studies were conducted to determine whether organisms capable of degrading TCE were present in groundwater from TAN (DOE-ID 2000). These studies revealed that three groups of bacteria (i.e., methanotrophs, propane oxidizers, and phenol oxidizers) capable of TCE degradation are indigenous to TAN groundwater. In further laboratory studies, the methanotrophs and phenol oxidizers were shown to degrade TCE co-metabolically. The propane oxidizers were not evaluated because of their slow growth rates. In addition, substrates (in particular, methane and oxygen) were detected in TAN groundwater at concentrations sufficient to fuel the process of co-metabolic oxidation.

Presently, studies are underway to provide direct evidence and further definition of the mechanism for co-metabolic oxidation of TCE. Direct evidence for co-metabolic oxidation of TCE in the plume and its potential outside the plume will greatly reduce any uncertainty regarding MNA performance and will alleviate the need for the contingent pump-and-treat remedy.

4.2.1.1 Water Chemistry Data Available for Calculation of the Degradation Rate Constant. The TCE and tritium concentration data are available from wells located near the axis of the TAN plume. Many of the wells have been monitored since the early 1990s. Results are available from 98 independent samples taken from these wells. These results comprise an extensive set of TCE and tritium data.

Two limitations of the set of data should be noted. First, the 1990 sludge-removal activity at TSF-05 might have disproportionately reduced the tritium source (Sorenson 2000). Because this removal action might have artificially caused changes in the contaminant-to-tracer ratios near TSF-05, the data between Wells TSF-05 and TAN-39 could not be used for the tracer-corrected approach (Sorenson et al. 2000). Secondly, the re-injection of treated water from the NPTF has begun to affect the contaminant monitoring in nearby Well TAN-48. For the purposes of this method, contaminant and tracer data from Well TAN-48 after August 2000 are unreliable and have been excluded from the data set.

Groundwater velocity is a critical parameter in the degradation rate calculation. Using tritium data from five wells along the plume axis and correcting for radioactive decay, Sorenson et al. (2000) estimated average groundwater velocity to be 0.11 m/day (0.35 ft/day). Although transverse dispersion could, in fact, slow the apparent longitudinal velocity, resulting in an underestimate of velocity as measured in these five axial wells, this value represents a lower-bounding value of the groundwater velocity[a] and is conservative as used in the degradation rate calculation. Use of this value will underestimate the rate of degradation.

4.2.1.2 Calculation of the Degradation Rate Constant. The ratio of TCE to tritium concentrations (corrected for radioactive decay) at varying distances from the injection point is plotted on Figure 4-3. In this figure, results were compiled for wells that are located downgradient of TAN-39 near the axis of the plume. The data used in this figure range from 1988 to 2002, demonstrating that the analysis is temporally, as well as spatially, consistent.

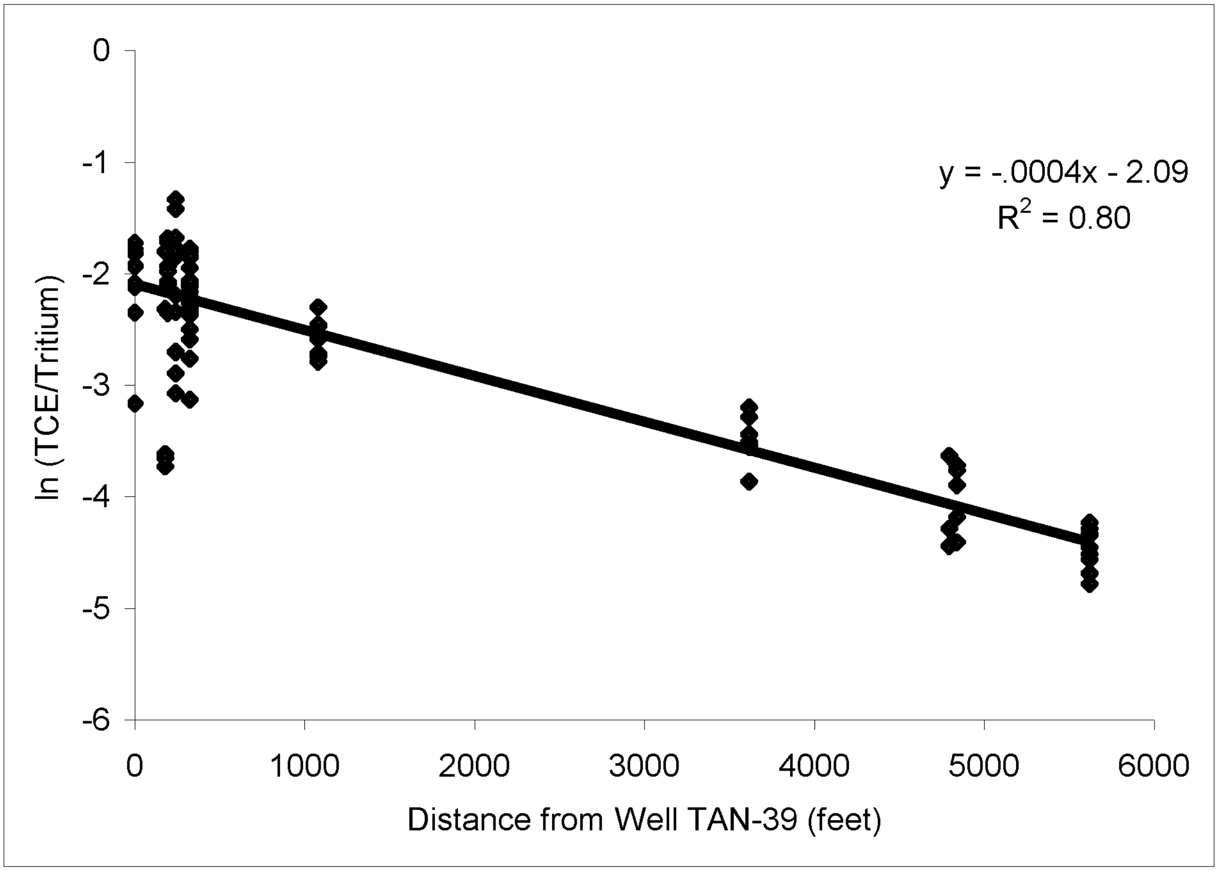


Figure 4-3. First-order degradation rate estimation using tracer-corrected trichloroethene concentrations.

As illustrated in Figure 4-3, the data indicate strong correlation between the ratio of TCE to tritium concentrations and distance from the injection point. Because the data are expressed in relation to a conservative tracer, the observed decline in concentration is an effective measure of true degradation, independent of dispersion or other geohydrologic processes.

The TCE degradation rate is estimated from the slope of the regression by converting the distance (the X-axis in Figure 4-3) to time, assuming a 0.11-m/day (0.35-ft/day) average groundwater velocity. The resulting degradation rate, expressed as a half-life, is 13 years. The corresponding 95% confidence interval on the slope of the regression equates to half-lives of 12 to 15 years.

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a. A numerical flow model calibrated to tritium data predicts an average velocity of 0.15 m/day (0.49 ft/day), which is greater than that used in the rate calculation (Sorenson et al. 2000).

The PCE data also were examined, as suggested by Sorenson et al. (2000). Although PCE is subject to minor volatilization and sorption, it is resistant to biodegradation processes and is relatively conservative compared to TCE. However, the degradation rate estimate using PCE as a tracer is less accurate than that calculated using tritium as a tracer. It is expected that the degradation half-life estimated from the TCE/PCE data set will be longer than that estimated from the TCE/tritium data set, because some sorption of PCE might occur. The TCE half-life estimated using PCE data was 24 years (with upper and lower 95% confidence limits of 22 and 26 years, respectively). Analysis of the TCE/PCE data set, which was even larger than the TCE/tritium data set, provided additional confidence in the tracer-corrected method.

Clearly, tritium is a conservative tracer and can be used with the tracer-corrected method to estimate the actual degradation rate of TCE independent of geohydrological processes such as sorption and dispersion. For the purposes of monitoring remedy performance, a conservative estimate of TCE half-life is best estimated by using tritium data combined with a bounding lower estimate for groundwater velocity, as described previously. The detailed information supporting this estimation of degradation rate is found in Engineering Design File (EDF) -3739, "Degradation Rate Coefficient for Aerobic Trichloroethene Attenuation (Draft)."[b]

4.3 Implications for Monitoring Parameters

The Field Demonstration Report (DOE-ID 2000) documented strong, but indirect evidence for an aerobic degradation mechanism that could naturally remediate TCE in the plume's distal zone. The results of the treatability studies indicated that attenuation is occurring in the aerobic part of the plume and that the mechanism appears to be oxidative. Organisms that are capable of co-metabolically oxidizing TCE and substrate sufficient to fuel the process have been demonstrated to be present in TAN groundwater.

During the performance of MNA, an important monitoring parameter will be the development of direct evidence that co-metabolic processes occur naturally in the aquifer. Verification of the biological mechanisms, as discussed in the next section, will provide the Agencies assurance that TCE will be degraded consistently over the life of the remediation.

The MNA performance also will be tracked by periodic measurement of COC concentrations throughout the contaminated groundwater plume. Concentration data of sufficient quality and quantity will be collected to ensure that observed trends in the data support the predicted attenuation rates for all COCs. The specific components of MNA performance evaluation are discussed in the next section.

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b. EDF-3739, 2003, "Degradation Rate Coefficient for Aerobic Trichloroethene Attenuation (Draft)," Idaho National Engineering and Environmental Laboratory, June 2003.

5. TECHNICAL ASSESSMENT OF MONITORED NATURAL ATTENUATION

The MNA remedy's effectiveness will be measured ultimately by assessing whether the RAOs will be achieved at the end of long-term operations. However, interim performance of the remedy will be assessed continually during the operational period. The TCE and radionuclide concentration data will be evaluated periodically to verify that observed conditions support a conclusion that RAOs will be met as expected. In addition, mechanisms of TCE degradation will be evaluated to provide direct evidence that co-metabolic processes occur naturally in the aquifer.

This section discusses how MNA performance will be assessed during the remedial action's operational phases. This evaluation entails five components, as follows:

- Verifying biological mechanisms
- Updating the numerical transport model
- Evaluating TCE data
- Evaluating radionuclide data
- Monitoring the size of the contaminated groundwater plume.

5.1 Verification of Biological Mechanisms for Trichloroethene Degradation

The tracer-corrected studies, identification of bacteria and substrates, laboratory studies, and nondegrading and degrading numerical modeling studies provided strong, indirect evidence that TCE might be degrading in the TAN plume's aerobic distal zone. However, direct evidence of a degradation mechanism has not yet been documented.

Study techniques will be identified and investigated to provide direct evidence of active degradation mechanisms within and outside areas of contamination at TAN. One promising approach utilizes activity-dependent probes to evaluate active mechanisms for degradation in the SRPA. Activity-dependent probes, which were developed by researchers at the Idaho State University and INEEL (Miller et al. 2002), are substrates that are transformed into fluorescent products by enzymes known to co-metabolize TCE. If the appropriate enzyme is present and active within a given environmental sample, then application of the probes to that sample should result in an easily detected fluorescent product. If the appropriate enzyme is not present or is present but inactive in a given sample, then the probes will not be transformed and no fluorescence will be detected. Direct evidence of an active degradation mechanism will verify the capability of MNA processes to naturally remediate TCE in the SRPA and may be used to support the Agencies' determination that MNA is operational and functional throughout the plume.

5.2 Evaluation and Adjustment of the Numerical Transport Model

A numerical model that simulates the transport of TCE is useful in evaluating the effectiveness of the MNA component of the remedy. The numerical model provides an effective method of integrating a complex set of conceptual model elements to predict transient conditions and contaminant distributions. A detailed numerical model was developed previously and used to verify that MNA would be an effective remedy at this site. The numerical model will be updated, as necessary.

The numerical model will be recalibrated using the best estimate of the TCE degradation rate and the most recent data. Updated TCE concentration isopleths and predicted trends will be constructed. Sensitivity analyses will be performed to assess the effects of boundary estimates of the degradation half-life on MNA. Furthermore, an analysis of vertically distributed concentration data will be conducted to determine whether the conceptual model and numerical model need to be revised to better simulate MNA processes. A model verification report will be prepared for release in 2005.

During performance operations, measured concentrations will be compared to simulated concentrations to verify the model's capability to adequately simulate contaminant transport and to evaluate MNA's effectiveness. If the numerical model does not adequately represent available TCE data, the conceptual model will be reevaluated and the numerical model will be updated and recalibrated. The updated model then will be used to determine MNA's effectiveness in achieving RAOs. During the long-term monitoring phase, the numerical model will continue to be used as a tool for evaluating the remedy's effectiveness.

5.3 Evaluation of Trichloroethene Concentration Data

During performance operations, the collected groundwater-monitoring data will be evaluated annually to confirm that TCE is being transported and degraded as expected. For monitoring wells that have historical data of acceptable quality, those data also will be used for MNA performance evaluation. As discussed in Section 2, the duration of performance operations might be different for Zones 1 and 2. In the case of Zone 1, it is expected that sufficient data will be available within 10 years to support this evaluation. The Remedial Action Report will summarize these evaluations and other data for review by the Agencies to determine whether MNA is operational and functional.

The year when peak TCE concentration occurs will be estimated for each monitoring well location using the updated numerical model and TCE degradation rate discussed in Section 4. Although the TCE concentration predictions are based on the best available information, significant uncertainty is inherent in the conceptual and numerical models used for these estimates. It is not expected that observed monitoring data will exactly match the predictions in either concentration or timing, because the predictive model is a mathematical simplification of a complex natural system. To account for this uncertainty, two breakthrough curves will be developed, which will (1) represent the best estimate of the peak concentration year and (2) represent the bounding estimate that indicates the latest time that breakthrough can occur and still ensure that RAOs will be met by 2095.

To evaluate MNA's progress, concentration data will be analyzed using statistical techniques to test for trends. The trend analyses will include the evaluation of goodness of fit, data variability, and the analysis of error associated with sampling and analytical methods and model predictions. An appropriate statistical trend analysis will be used to confirm or deny that the peak breakthrough of TCE has occurred at a time sufficient to meet RAOs. Negative (declining) trends observed in the data, with a 95% confidence limit, during the time between the best estimate and bounding estimate of breakthrough will indicate that degradation is occurring as expected and that COC concentrations are trending toward their MCLs.

5.4 Evaluation of Radionuclide Concentration Data

Radionuclides—including tritium, strontium-90, cesium-137, and uranium-234—were injected into the SRPA in Well TSF-05 during waste disposal operations. These radionuclides remain in the sludge around the injection well, but most are not detected in wells away from TSF-05. The limited mobility of these radionuclides is attributed to attenuation processes of radioactive decay and sorption of radionuclides to aquifer materials. Tritium is the only radionuclide that is detected extensively in the contaminant plume, because it is chemically conservative and is transported with groundwater flow. The Record of Decision Amendment (DOE-ID 2001a) indicated that radionuclides in the groundwater at TAN would attenuate naturally through sorption and decay to meet RAOs. The remedial action's MNA component includes the monitoring of radionuclides to evaluate flux from the secondary source, as presented in Table 2-2.

Contaminants leaching from the secondary source at TSF-05 migrate downgradient along local groundwater flow paths. Distribution of radionuclide concentrations in groundwater downgradient from Well TSF-05 is controlled, in part, by radioactive decay. With the exception ofuranium-234, the half-lives of COCs range from 12.32 years for tritium to 30.23 years for cesium-137. For these radionuclides, decay alone will reduce concentrations below MCLs. The long half-life of uranium-234 (2.45×10^5 years) minimizes attenuation of this radionuclide through decay.

Sorption processes work in concert with radioactive decay to attenuate concentrations of radioactive COCs with distance from the injection well. Strontium-90, cesium-137, and uranium-234 all strongly sorb to the aquifer matrix. Figure 4-2 is a plot of strontium-90 concentration with distance from the injection well. This figure illustrates that the observed decline in strontium-90 concentrations is much greater than would be attributed to radioactive decay alone. Hence, processes other than radioactive decay are reducing concentrations of strontium-90. These processes probably include sorption and co precipitation with calcite.

During the remedy, radionuclide concentrations will be monitored to evaluate potential mobilization of radionuclides in response to ISB remediation and to evaluate attenuation through decay or sorption. As with TCE data, radiological data will be evaluated at the end of the remedy to verify that RAOs have been achieved.

5.5 Evaluation of Plume Dimension Changes

With MNA, the size of the TCE plume (as defined by the 5-µg/L isopleth) is predicted to increase in size before decreasing in response to natural attenuation. Based on the current understanding of the area's hydrogeology, the plume is expected to expand primarily through an increase in the plume length, with minimal lateral expansion. In the Record of Decision Amendment (DOE-ID 2001a), the Agencies determined that plume expansion of up to 30% is anticipated and acceptable during the remediation period. However, plume expansion in excess of 30% may not be considered protective.

The 30% plume expansion will be determined based on the extent to which the length of the plume along the major axis increases. It is assumed that TAN-56 is located on or near the longitudinal axis of the plume and represents an approximate 15% plume expansion point. Data collected from Zone 3 wells will be evaluated periodically (the sampling frequency for Zone 3 is set at every 3 years in Section 7) to determine whether concentrations in Zone 3 are increasing above allowable limits. The decision process for Zone 3 is discussed in Section 7.4. Wells TAN-57 and TAN-58 will provide additional information about changes in plume width and direction.

5.6 Data Quality Objectives

The ongoing evaluation of MNA's effectiveness will require that extensive environmental data be collected over the remedial action's lifespan. A defensible and well-designed sampling process has been developed using the DQO process. The DQO process is a series of planning steps designed to ensure that data of known and appropriate quality are obtained to support remedial response decisions (EPA 2000a, 2000b). The process uses qualitative and quantitative statements intended to clarify study objectives, define appropriate data types, and specify acceptable levels of decision errors. The outputs of each step are then used as inputs in designing the sampling plan. In the case of MNA, many DQO process elements were developed previously in a cooperative fashion amongst the Agencies. As discussed in Section 2, the Record of Decision Amendment (DOE-ID 2001a) and performance- and compliance-monitoring strategy (INEEL 2003) clearly present groundwater monitoring objectives, appropriate data types, decision criteria, and basic requirements of the sampling plan. Appendix C presents the DQO development process for MNA, as derived largely from information developed in the Record of Decision Amendment and performance- and compliance-monitoring strategy. The sampling and analysis design, as presented in Section 7, is based on the results of these planning steps.

6. INFRASTRUCTURE

Only minor infrastructure modifications and additions are required for MNA operations startup. This work will consist primarily of well maintenance activities on existing monitoring. New infrastructure requirements for the MNA program may be identified after operations have begun and may consist of new wells and/or the installation of FLUTe™ liners in selected wells for the vertical characterization of contaminants. This section addresses the planned minor infrastructure modifications and FLUTe™ completion guidelines before commencement of MNA performance operations.

6.1 Organization

Throughout the project, the DOE-ID project remediation manager will be responsible for notifying the EPA and IDEQ of project activities and will serve as the single interface point for all routine contacts among the Agencies and the management and operations contractor. The management and operations contractor shall be responsible for implementing the remedial action. This includes design, field activities, waste management, health and safety, quality assurance, and all other tasks necessary to complete this remedial action. The *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan* (INEEL 2002a) includes the near-term project organizational chart and a role and responsibility description. This organizational chart may be adjusted from time to time as circumstances dictate.

6.2 Construction

No construction will take place before implementation of the MNA remedy. Therefore, no construction items must be inspected during the prefinal inspection. Construction activities that may occur during the MNA remedy include the following:

- Monitoring wells may be installed in accordance with project plans and specifications
- FLUTe™ liners may be installed in accordance with project plans and specifications
- Monitoring wells may be improved with dedicated sampling equipment.

6.3 Agency Inspections and Acceptance

Upon completion and approval of the MNA Work Plan, the project team will compile an MNA Monitoring and Operations Manual for implementing performance operations. Upon completion of this manual, an Agency MNA prefinal inspection will be scheduled, as described in the following sections. After inspections are completed, a report will be prepared to document any issues identified during the inspection and the proposed corrective action.

6.3.1 Prefinal Inspection

Before start of operations, the Agencies' project managers (or their designees) shall conduct a prefinal inspection. A prefinal inspection checklist shall be prepared and agreed to by the Agencies before performing the inspection. Open items will be recorded during the prefinal inspection, and an action will be identified to resolve the open items. At the end of the inspections, the Agencies will determine which open items require closure before proceeding with performance operations. Upon acceptance of the prefinal inspection report, performance operations may begin.

6.3.2 Prefinal Inspection Report

A prefinal inspection report will be prepared to document the prefinal inspection results. The report will identify the open items from the inspection, the agreed-upon action for closing the open items, and the scheduled closure date for each open item. The prefinal inspection report will be prepared in December 2003 as a secondary document for review by the Agencies. The prefinal inspection report will include the following:

- Completed prefinal inspection checklist
- Identification of open items
- Actions and schedules for closure of open items
- Planned date for final inspection (if required).

6.3.3 Final Inspection

If required, a final inspection shall be performed beginning in December 2003. This final inspection will focus on any unresolved issues from the prefinal inspection.

6.3.4 Final Inspection Report

A final inspection report shall be prepared to document the final inspection results. The report shall address the following:

- Resolution of any outstanding items from the prefinal inspection
- Explanation of any changes from the remedial design and Remedial Action Work Plan
- A Remedial Action Work Plan and Operation, Maintenance, and Monitoring Plan update, if necessary.

7. MONITORED NATURAL ATTENUATION OPERATIONS

This section identifies the requirements for MNA groundwater monitoring. The groundwater monitoring requirements are derived from the RAOs and performance goals defined in the Record of Decision Amendment (DOE-ID 2001a) through the DQO process. The output of the DQO process is a groundwater-monitoring strategy designed to assess progress toward, and completion of, the RAOs and performance goals.

Data collected through groundwater monitoring activities will be used specifically to assess the remedy's performance and to support Agency performance and compliance reviews. This section of the Remedial Action Work Plan covers:

- Groundwater monitoring requirements
- Operational procedures and protocols
- Data analysis and interpretation
- Operational decision-making
- Preventative maintenance and inspections
- Institutional controls
- Remedy performance review and reporting
- Best management practices.

The Operations, Maintenance, and Monitoring Plan (DOE-ID 2003a) will implement the requirements of this section.

7.1 Groundwater Monitoring Requirements

This section presents the requirements for the MNA groundwater-monitoring program. These requirements are based on the monitoring strategy described in Section 2 and the results of the DQO process described in Appendix C. The first operational phase, "Performance Operations," allows for a period of annual data collection and analysis to confirm the remedy's effectiveness. The second phase, "Long-Term Operations," consists of confirmatory monitoring to track progress toward achieving RAOs for the duration of the 100-year operational period.

7.1.1 Performance Operations Phase

During performance operations, groundwater samples will be collected from a representative set of wells in each of the three zones, as described in Table 7-1. Wells were selected to be representative of hydrologic conditions and historic distribution of contaminants. Sampling frequency was determined based on historic data trends. Analytical parameters were identified in the DQO process and consist primarily of COCs listed in the Record of Decision Amendment (DOE-ID 2001a). Zone 1 performance-monitoring wells include TAN-15, TAN-51, TAN-54, and TAN-55 for VOC contaminants and TAN-25, TAN-28, TAN-29, TAN-30A, TAN-37, and TSF-05 for radionuclide contaminants. Zone 2 performance-monitoring wells include TAN-21, TAN-52, and ANP-8. Zone 3 monitoring wells include TAN-56, TAN-57, TAN-58, and GIN-4.

Table 7-1. Summary of the monitoring requirements for performance operations.

Zone	Frequency	Location	Parameters
1	Annual	TAN-16, TAN-51[a], TAN-54[a], and TAN-55[a]	TCE, PCE, cis- and trans-DCE, VC, H-3
		TAN-25, TAN-28, TAN-29, TAN-30A, TAN-37[a], and TSF-05[a]	Gross alpha, Sr-90, Cs-137, H-3
2	Annual	TAN-52[a], TAN-21, and ANP-8	TCE, PCE, cis- and trans-DCE, VC, H-3
3	Every 3 years	GIN-4, TAN-56[a], TAN-57, and TAN-58	TCE, PCE, cis- and trans-DCE, VC, H-3

a: Well is sampled at multiple depths.
DCE = dichloroethene
PCE = tetrachloroethene
TAN =Test Area North
TCE = trichloroethene

Monitoring of VOC contaminants in Zone 1 will be performed to determine whether peak TCE concentration breakthrough has occurred at these wells, as predicted by previous modeling. Monitoring of radionuclide contaminants in Zone 1 will be performed to verify that radionuclide concentrations, combined with radioactive decay and observed rates of attenuation, will be below MCLs before 2095. Because historic radionuclide concentrations have been negligible in the plume's distal portion, radionuclide monitoring will be limited to a subset of wells near TSF-05 (Table 7-1).

Monitoring of VOC contaminants in Zone 2 will be performed to identify whether wells in this area exhibit peak concentration breakthroughs as predicted by previous modeling. Breakthrough at Zone 2 wells is expected to occur over a period between 2010 and 2020. Data collection to verify the occurrence of peak breakthrough at each well could extend another decade beyond the actual year of breakthrough.

Monitoring in Zone 3 will be performed to verify that the plume does not expand axially more than 30% beyond the downgradient extent of the 5-µg/L isopleth, which was estimated in the Explanation of Significant Differences (INEEL 1997). Samples will be collected from the selected Zone 3 wells once every 3 years and analyzed for VOC contaminants of concern. The Zone 3 monitoring plan may be revised, including the installation of a new downgradient-monitoring well, should data warrant.

7.1.2 Long-Term Operations Phase

Long-term operations will begin after performance operations for Zones 1 and 2 are complete. During this time, sampling activities will continue in monitoring wells according to the Agencies' requirements (to be determined) and described in the Remedial Action Report(s).

Periodic sampling will be conducted to support the continued evaluation of MNA's effectiveness, as described in Section 5. At completion of NPTF and ISB remedial activities, the Agencies may choose to monitor for contaminants in additional wells completed in the upgradient part of the plume (see Figure 2-1). Long-term operations will be complete when RAOs have been achieved.

7.1.3 Sample Collection Using FLUTe™ Liners

The MNA monitoring wells—TAN-51, TAN-52, TAN-54, TAN-55, and TAN-56—are equipped with FLUTe™ liners to allow samples to be collected at specific depths in the aquifer. Data collection at different depths provides information about the vertical distribution of contaminants in the aquifer. This type of sampling design represents a stratified sample collection method (EPA 2000b). The goal of using these data as a best management practice is to identify the presence or absence and possible trends in TCE and radionuclide concentrations with respect to depth. This sampling design will identify vertical areas of interest and help to evaluate MNA's effectiveness with respect to investigating the degradation mechanisms and evaluating the TCE and radionuclide concentration trends detailed in Section 5.

Implementation of a stratified sample collection method includes dividing the aquifer into two or more non-overlapping strata and collecting samples from each stratum (EPA 2000b). For the MNA monitoring wells, the depths of different wells can be grouped together as a stratum division, with samples collected from each stratum. Stratum divisions cannot necessarily be divided based on matching depth ranges, because the heterogeneous nature of basalt fractures precludes continuous correlation at specific depth ranges throughout the aquifer.

The advantages of using a stratified sample collection method include determining information about contaminant concentrations in each specific stratum and determining concentrations for the entire vertical extent of the aquifer. If there appears to be a stratum of particular interest, additional sample collection or extended monitoring can be conducted for just that stratum. Specific to the MNA monitoring wells, this sampling method can show the vertical distribution of TCE and radionuclide concentrations. This information may be used to identify contaminant isopleths for the different strata and possibly detect concentration trends in each stratum.

One round of FLUTe™ sampling was conducted in 2002 at TAN-51, TAN-52, TAN-54, and TAN-55. These data are being evaluated. A FLUTe™ liner was installed in TAN-56 following the 2002 sampling round. The collection of FLUTe™ data will take place during the MNA performance operations phase, and the data will be evaluated in the annual MNA performance reports. Upon completion of the performance operations phase, decisions regarding the continuation of FLUTe™ data collection and addition of FLUTe™ liners or a similar technology to other wells will be evaluated in the Remedial Action Report.

7.2 Operational Procedures and Protocols

Operational procedures and protocols shall be developed as part of the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) to govern and guide the implementation of MNA remedial action monitoring activities. These procedures and protocols shall be prepared so that requirements defined by site work control; this Remedial Action Work Plan; the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a); and ARARs are met. The following operations and activities shall have procedures and protocols developed:

- Groundwater monitoring
- Well maintenance
- Data management.

7.3 Data Analysis and Interpretation

Data analysis and interpretation are critical to the success of the MNA remedial component. Clear performance and compliance goals have been developed, and a phased implementation approach is planned. Data analysis and interpretation, as described in Section 5, will provide the means for the project and the Agencies to make decisions regarding MNA performance and compliance.

7.4 Operational Decision-Making

The phased implementation approach allows the flexibility to modify the monitoring strategy to implement MNA more effectively and efficiently. Inherent in the review and interpretation of performance and compliance data is the opportunity to efficiently evaluate the capability of natural biodegradation processes to meet RAOs. Following EPA guidance, DQOs including specific decision rules were developed to guide the interpretation of environmental data for this project (Appendix C). A summary of the decision rules is provided in Table 7-2.

7.5 Preventative Maintenance and Inspections

To ensure that wells selected for MNA monitoring are available and in efficient operating condition for the long-term needs of the project, it is necessary to have in place an effective maintenance program. Integral to the program are thorough inspections, routine/as-required maintenance, and the comprehensive documentation of all activities. The Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) will address preventative maintenance and inspection activities.

7.6 Institutional Controls

Institutional controls shall be implemented to prevent the use of contaminated groundwater until the RAOs specified in Section 2 have been attained throughout all areas of the contaminated aquifer. Institutional controls shall consist of engineering and administrative controls to protect current and future users from health risks associated with groundwater contamination. The institutional controls will prevent ingestion of contaminated groundwater. Institutional controls for OU 1-07B have been addressed in the *Final Record of Decision for Test Area North, Operable Unit 1-10* (DOE-ID 1999). These controls include visible restrictions, control of activities, prevention of well drilling, and control of land use.

Institutional controls will include establishment of an institutional control boundary that extends 40% beyond the current dimensions of the 5-µg/L isopleth (see Figure 2-1). This boundary will accommodate the anticipated 30% plume expansion and will provide an extra buffer of 10%. The boundary will be clearly marked to protect against ingestion, inhalation, or dermal contact. The MNA-specific institutional controls are addressed in the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a).

7.7 Remedy Performance Review and Reporting

Reporting requirements for MNA are derived from the need to review the performance and compliance of MNA on a periodic basis and to judge the combined effect of MNA and the other remedial action components toward achieving total plume restoration. Three reporting requirements—consisting of periodic performance reviews, annual performance reports, and a remedial action report—are identified for MNA. In addition, reporting requirements include revisions to the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) and the production of a final Operations, Monitoring, and Maintenance report.

7.7.1 Performance Reviews

The Agencies will evaluate the performance and compliance monitoring activities at the completion of the performance operations phase. Periodic performance reviews will be conducted at least every 5 years throughout the long-term operations phase. Reviews that are more frequent may be conducted if circumstances warrant. The evaluation strategy for MNA effectiveness, presented in Section 5, will be implemented formally and documented in the course of these reviews. A final review will be conducted at the end of the remedy.

Table 7-2. Summary of decision rules for each implementation phase and monitoring zone (as developed in the Data Quality Objectives, Appendix C).

Boundaries		Parameters	Action levels	Decision rule
Performance Operations	Zone 1	Statistical trend in COC concentrations	No quantitative action level	If monitoring data indicate that (1) peak TCE breakthrough has occurred in Zone 1 monitoring wells prior to the bounding estimate of the year of peak breakthrough (in accordance with Section 5 of this report) and (2) radionuclide contaminants are attenuating at a rate that will achieve MCLs prior to 2095, then Agencies will determine that MNA is operational and functional in Zone 1 and long-term operations will commence. Otherwise, performance operations will be extended for a period to be determined by the Agencies.
	Zone 2	Statistical trend in COC concentrations	No quantitative action level	If MNA is determined to be operational and functional in Zone 1, and if scientific studies identify direct evidence of an active degradation mechanism that verifies the capability of MNA processes to naturally remediate TCE in the SRPA, then MNA in Zone 2 will be determined by the Agencies to be operational and functional and long-term operations will commence. Otherwise, performance operations will continue until monitoring data indicate that peak TCE breakthrough has occurred in Zone 2 monitoring wells prior to the bounding estimate of the year of peak breakthrough (in accordance with Section 5 of this report).
Long-Term Operations	Zone 3	Maximum TCE concentrations	10 µg/L	If TCE concentrations measured in GIN-4 exceed 10 µg/L, then the monitoring plan will be revised, including increasing sampling to an annual frequency.
		Maximum TCE concentrations	10 µg/L	If TCE concentrations measured in TAN-56 exceed 10 µg/L, then the monitoring plan will be revised, including but not limited to installation of a further downgradient-monitoring well. The new monitoring well will be located at a point to measure a 30% increase in plume size. That is, the well will be at a distance 1.3 times the length of the plume, measured along the primary plume axis, as estimated by the 5-µg/L isopleth drawn in the Explanation of Significant Differences (INEEL 1997).
		Maximum TCE concentrations	5 µg/L	If TCE concentrations remain less than 5 µg/L at a point corresponding to a 30% increase in plume size, then MNA will be operational and functional in Zone 3. Otherwise, MNA will not be considered operational and functional in Zone 3, and it will require reevaluation by the Agencies and modification of the remedy, as necessary.
	All Zones	TBD in Remedial Action Report	MCLs and cumulative risk levels in Record of Decision Amendment (DOE-ID 2001a)	If the groundwater data indicate that remedial objectives have been met, then no further action is required at the site and the Agencies can proceed with de-listing procedures. Otherwise, the Agencies shall determine whether further response is appropriate for the site.

7.7.2 Annual Monitored Natural Attenuation Performance Report

Data obtained from annual sampling activities will be compiled in the Annual Performance Report, at least through the MNA performance operations phase, as specified in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b). After the performance operations phase is complete, the subsequent frequency of reporting will be identified in the Remedial Action Report. This data compilation will be summarized with other remedial components in an annual remedy performance summary report that will discuss remedial-component regulatory performance and compliance with RAOs, budgetary performance, and institutional controls, as described in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b).

7.7.3 Model Verification Report

Recalibration of the MNA numerical model will be documented in the Model Verification Report, which will be prepared in 2005. The report will describe recalibration efforts and the results, including TCE breakthrough curves generated using the revised TCE degradation half-life.

7.7.4 Remedial Action Report

As specified in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b), an MNA Remedial Action Report will be prepared after the performance operations phase is complete. The Remedial Action Report will be a primary document submitted according to the schedule in Section 13 of this document.

The Remedial Action Report will discuss MNA implementation and the reasons for any changes. In addition, the Remedial Action Report will discuss and memorialize operational testing, shakedown operations, and final inspections. The evaluation of the remedy's effectiveness and other topics will result in a determination of whether the remedial action can be determined to be operational and functional. The Remedial Action Report will identify a schedule for modifying the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) in order to define any operational changes resulting from performance operations, and it will detail the requirements for determining completion of MNA in the distal zone.

7.7.5 Operations, Monitoring, and Maintenance Plan Revision

Revisions to the Operations, Monitoring, and Maintenance Plan that are identified during the MNA performance phase will be prepared subsequent to completion of the Remedial Action Report, as specified in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b). The completion milestone will be identified in the Remedial Action Report.

7.7.6 Operations, Monitoring, and Maintenance Report

The Operations, Monitoring, and Maintenance Report will be prepared after MNA activities at TAN are complete. The deliverable date will be presented in the Remedial Action Report.

8. WASTE MANAGEMENT

All waste generated during MNA will be managed in accordance with the provisions of the *Waste Management Plan for TAN Final Groundwater Remediation* (INEEL 2002b). Equipment and material decontamination requirements and procedures are specified in the *Interim Decontamination Plan for OU 1-07B* (INEEL 2002c).

All waste generated during the OU 1-07B remedial action will be managed and disposed of in accordance with applicable waste management requirements, including those contained in the Waste Certification Plan (Jones 1997) and the Idaho National Engineering and Environmental Laboratory Waste Acceptance Criteria (DOE-ID 2003b). All waste management activities will be conducted in accordance with the applicable substantive requirements of the Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq.).

Specific waste-management regulatory issues that are applicable to the distal zone component of the OU 1-07B remedy are summarized in the following sections. These include:

- RCRA-listed waste
- Low-level radioactive waste.

8.1 Resource Conservation and Recovery Act Listed Waste

8.1.1 Listed Waste Determination

The TSF-05 injection well was drilled in 1953 to a depth of 93 m (310 ft) to dispose of liquid effluent generated from the Aircraft Nuclear Propulsion project. Discharges to the well included organic sludge, treated sanitary sewage, process wastewater, and low-level radioactive waste streams. The principal VOC discharged was TCE. Estimates of the volume of TCE discharged to the well range from 1,325 to 97,161 L (350 to 25,670 gal). Previous evaluations of the solvents used at TAN concluded that the waste discharged to the injection well was not a RCRA-listed hazardous waste, because the organic chemicals in the waste were not used as solvents or for degreasing and the actual usage practices were not known (DOE-ID 1995).

In April 1997, based on new information, it was determined that a solvent (TCE) was disposed of at the TAN facility via the TSF-21 valve pit. Since the valve pit is connected with the TSF-05 injection well, the injection well and associated groundwater contamination plume are considered to contain the solvent. Therefore, the RCRA-listed waste classification, waste code F001, is applicable to the TCE-contaminated TAN groundwater and associated waste streams at the point of generation (when water is brought to the surface). The substantive requirements of the ARARs are applicable for the RCRA-listed waste (INEEL 1997). The listed waste determination was implemented for OU 1-07B for waste that was not previously determined to be characteristic based on the OU 1-07B Waste Management Compliance Commitments and Schedule dated July 22, 1997. This was concurred with by the Agencies in a U.S. Department of Energy (DOE) letter from K. E. Hain (Environmental Restoration [ER] program manager) to K. L. Falconer (ER director) dated August 29, 1997.[c]

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c. Hain, K. E., DOE-ID, Manager of Environmental Restoration Program, to K. L. Falconer, INEEL, Director of Environmental Restoration, August 29, 1997, DOE-ID letter OPE-ER-129-97.

8.1.2 No-Longer-Contained-In Determination

Environmental media are considered to potentially contain RCRA-listed hazardous waste if there was a release to the media that included the types of waste defined in 40 CFR 261.3, "Definition of Hazardous Waste." One of the options available to manage waste containing low to undetectable concentrations of listed waste is to request a no-longer-contained-in determination for these environmental media, soil, and groundwater. Until a no-longer-contained-in determination is made for the OU 1-07B waste streams, the waste will be managed as a listed hazardous CERCLA waste in accordance with the *Waste Management Plan for Test Area North Final Groundwater Remediation Operable Unit 1-07B* (INEEL 2002b). The no-longer-contained-in determinations that have been approved are attached to the Waste Management Plan.

8.1.3 Monitored-Natural-Attenuation Sampling Purge Water

Because of this listed waste determination, all water extracted from the OU 1-07B groundwater plume must be handled in such a way as to meet the substantive requirements of the ARARs for RCRA-listed waste. As part of the MNA remedial component, routine groundwater sampling produces significant quantities of purge water. This purge water shall be collected throughout sampling activities and shall be processed through the NPTF throughout the NPTF's operational life. Purge water from sampling after completion of NPTF will be addressed in the Remedial Action Report. The NPTF discharge requirements for air and water effluent remain the same for the purge water, as with routine NPTF extraction well water.

8.2 Low-Level Radioactive Waste

Low-level radioactive waste may be generated during OU 1-07B MNA activities. This waste is the result of radionuclide contamination in the TSF-05 injection well and is primarily associated with the sludge from the TSF-05 well. Usually, this radioactive waste also contains RCRA F001-listed waste; therefore, it is classified as listed mixed waste.

9. DECONTAMINATION AND DECOMMISSIONING

Decontamination is a process whereby contaminants that have accumulated on or in equipment, tools, or treatment systems are removed or neutralized such that they no longer present a hazard to human health or the environment. Decontamination efforts associated with OU 1-07B have been grouped into two activities. These two activities include (1) those that are involved with day-to-day operations and investigations (i.e., interim decontamination) and (2) those that are associated with the final shut down and decommissioning of any treatment facilities used to remediate the OU (i.e., final decontamination).

9.1 Interim Decontamination

Detailed decontamination procedures can be found in the *Interim Decontamination Plan for Operable Unit 1-07B* (INEEL 2002c). Decontamination of the tanks, containers, and equipment used for the remedial actions associated with OU 1-07B involves removal and disposal of waste present in the containers and decontamination of the interiors of tanks, containers, and associated ancillary equipment in contact with waste (as necessary). Decontamination consists of rinsing the item to be decontaminated with water to meet the performance criteria in the Interim Decontamination Plan (INEEL 2002c). Spent decontamination water and other liquid waste streams generated during the decontamination process will be assessed for compatibility with NPTF operations. The compatible waste streams will be transferred to the NPTF for processing with the surge tank contents. Those waste streams that are incompatible with NPTF operations will be sampled and analyzed for characterization in accordance with the Waste Management Plan (INEEL 2002b).

9.2 Final Decontamination and Decommissioning

Final decontamination and decommissioning (D&D) of OU 1-07B treatment systems will be addressed after the Agencies determine that the active remediation is complete and/or that the treatment systems are no longer required. The D&D requirements for each treatment system will be addressed in future D&D plans. In general, the D&D plans will direct that—for the facilities built to remediate OU 1-07B—all tanks, containers, piping, and equipment be flushed with clean water to remove as much contamination as possible. The system will be dismantled and made ready for decontamination, as directed by management. Components that can be decontaminated will be released for use in other systems or can be disposed of as industrial waste. The site will be returned to its preoperational condition to the extent feasible, considering cost and intended future use.

The wells that are placed in the area will continue to be used for aquifer monitoring or will be abandoned in accordance with INEEL procedures and applicable State regulations. Other equipment and facilities installed during the remediation activities will be dismantled, decontaminated, and disposed of in accordance with INEEL policy and procedures.

The OU 1-07B CERCLA waste storage unit adjoining the hot spot site will be left "as is" for storage (as needed). The waste stored within will be processed and disposed of as addressed in the Waste Management Plan (INEEL 2002b). These CERCLA waste storage units may be moved to other locations, if the need arises.

10. EMERGENCY RESPONSE

Emergency response is covered in Plan (PLN) –114-4, “Emergency Preparedness—Addendum 4—Test Area North (TAN).” The Health and Safety Plan (INEEL 2002a) contains primary emergency response actions for OU 1-07B site personnel, including initial responses, task site responsibilities, emergency equipment at the task site, emergency response teams, and notification lists. This section of the HASP supplements PLN-114-4. Copies of both of these documents are kept in the OU 1-07B office, which is located in the TAN–607 building. A copy of the HASP also will be kept in the Hazardous Communications Center, which is located at the OU 1-07B remediation site.

Emergency response organizations and operational emergency event classes are included in PLN-114-4 for the following:

- Fires
- Explosions
- Radiological releases
- Nonradiological releases
- Natural phenomena
- Loss of power
- Criticalities
- Safeguards and security
- External events.

Sections 5 through 14 of the contingency plan address notifications and communications, consequence assessment, protective actions, medical support, recovery and reentry, public information, emergency facilities, training (in the Health and Safety Plan [INEEL 2002a]), drills and exercises, and program administration. The OU 1-07B Appendix “L4,” which is specific to the OU 1-07B project and defines specific measures and criteria used for OU 1-07B activities, is included in PLN-114-4.

Emergency actions are governed primarily by the Health and Safety Plan (INEEL 2002a); however, when emergencies occur that are beyond the Health and Safety Plan’s limitations, then PLN-114-4, “Emergency Preparedness—Addendum 4—Test Area North (TAN)” will be implemented. Therefore, in the event of an emergency, initial responders shall follow the directions of the Health and Safety Plan unless the resulting emergency is designated as a fire, explosion, or an uncontrolled release to the environment, in which case PLN-114-4 will be implemented.

11. QUALITY ASSURANCE PROGRAM

This report is intended to be used in conjunction with the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10, and Inactive Sites* (DOE-ID 2002) and PLN-694, "Environmental Restoration Program Management." The most important activities associated with the MNA distal zone's remedial component, with respect to quality assurance, are the data collection and analysis activities for compliance and performance monitoring. The quality assurance for these activities is described in detail in the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) for compliance monitoring, performance monitoring, and facility operational activities.

12. SAFETY AND HEALTH PROGRAM

The Health and Safety Plan (INEEL 2002a) establishes the procedures and requirements that will be used for all activities associated with OU 1-07B. The major field activities for MNA are monitoring well installation, FLUTe™ liner installation, and groundwater sampling. The Health and Safety Plan includes a hazard assessment for all anticipated activities and specifies procedures and equipment to be used for worker safety.

The safety and health requirements for MNA remedial action activities include the areas of industrial safety, industrial hygiene, fire protection, radiation safety, and emergency preparedness. Safety and health requirements—in accordance with 29 CFR 1910.120 and 1926.65, "Hazardous Waste Operations and Emergency Response"—are designed and established to provide a safe and healthy work environment. Safety and health requirements are being implemented at the INEEL through the DOE Integrated Safety Management System and the Voluntary Protection Program. The Integrated Safety Management System and Voluntary Protection Program integrate hazard identification and mitigation into the work control process for construction, operations, and maintenance activities.

13. SCHEDULE AND BUDGET

This section addresses cost, schedule, and deliverables for MNA distal zone remediation activities. A cost comparison of the current project baseline and the cost estimate in the Record of Decision Amendment (DOE-ID 2001a) also is included. The Record of Decision cost estimate has been revised for this report to reflect the refined ISB costs that were presented in the *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2003c), which are slightly higher than those presented in the Record of Decision Amendment (DOE-ID 2001a).

13.1 Record of Decision Cost versus Current Baseline

Outyear funding availability for remedial design/remedial action projects is subject to Congressional approval of DOE budgets. The DOE has identified adequate funding in existing budget plans for this project. Table 13-1 contains the project cost estimate from the Record of Decision Amendment (DOE-ID 2001a). This estimate and the assumptions contained in it may be used for comparison throughout the project. Depending on the outcome of the specified Record of Decision Amendment and Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b) decision points, the actual remediation costs are expected to be within -30 to +50% of the Record of Decision Amendment cost estimate.

13.2 Cost Estimate

Currently, the only construction cost item identified for MNA is the installation of a FLUTe™ Liner in Well TAN-56. This estimate is based on the MNA implementation and operation, as described by this Remedial Action Work Plan.

13.3 Schedule

The documents submitted to the EPA and IDEQ as deliverables are presented in Table 13-2, with the corresponding submittal dates, in accordance with Section XII of the FFA/CO (DOE-ID 1991). Milestone deliverable dates presented in Table 13-2 were established in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001b), and where applicable, as modified by subsequent Agency agreement.

Documents will have expedited and nonexpedited review and revision schedules. The review periods vary depending on the document. Draft primary documents (nonexpedited) have the standard 45-day review period. Secondary documents will have the standard 30-day review period. The DOE review will be concurrent with the EPA and IDEQ review.

Figure 13-1 is the MNA remedial design/remedial action schedule containing the activities and interfaces necessary to accomplish the task detailed in this Remedial Action Work Plan. The schedule ends with the completion of MNA performance operations; long-term operation schedule activities will be detailed in a future revision to the Operations, Monitoring, and Maintenance Plan (DOE-ID 2003a) following issue of the Remedial Action Report.

Table 13-1. Remedial Design/Remedial Action Work Plan cost summary for monitored natural attenuation at Operable Unit 1-07B.

Description	Baseline Cost Estimate[a, b, c] FY 1999 ($)	Record of Decision Cost Estimate[a, b, c] FY 1999 ($)
MNA design[d] (MNA Remedial Action Work Plan FY 2003 [$])	190,724	—
MNA construction[e]	76,290	—
MNA operations and maintenance (FY 2004 to FY 2030)	2,095,740	2,095,740
MNA decontamination and dismantlement[f]	302	—
Common elements (sunk costs, NPTF operations, ISB operations)	35,879,430[g]	33,319,158[g]
TOTAL	38,230,170[e]	35,414,898

Dollars are net present value with a discount rate of 7%.
The baseline cost estimate includes actual cost through FY 2001 and baseline-estimated cost for FY 2002 through FY 2018 (except as noted).
Costs were converted to FY 1999 dollars based on the construction cost index (http://www.enr.com/cost/costcci.asp).
Preparation of the MNA Remedial Action Work Plan ($250,000 in FY 2003) is not included in the Record of Decision cost estimate.
Includes $100,000 for FLUTe™ liner in FY 2003. (Note: The Record of Decision cost estimate did not include FLUTe™ liner costs.)
Assumes MNA D&D will be completed in FY 2095. The D&D costs were not included in the Record of Decision cost estimate.
Based upon revised cost summary from the ISB Remedial Action Work Plan (DOE-ID 2003c, Table 14-1).
D&D = decontamination and decommissioning
DOE-ID = U.S. Department of Energy Idaho Operations Office
FY = fiscal year
ISB = in situ bioremediation
MNA = monitored natural attenuation

Table 13-2. Agency deliverable documents.

Deliverable	Planned Submittal Date	Enforceable Submittal Date	Review Duration (days)	Document Type
Distal Zone Remediation	—	—	—	—
MNA Remedial Action Work Plan	January 2003	March 2003	45	Primary
MNA Prefinal Inspection Report	December 2003	March 2004	45	Primary
MNA Modeling Verification Report	September 2005	N/A	30	Secondary
Zone 1 Remedial Action Report	July 2013	September 2013	45	Primary
Zone 2 Remedial Action Report[a]	TBD	TBD	45	Primary
Operations, Monitoring, and Maintenance Plan, Revision[a]	TBD	TBD	45	Primary
MNA Annual Performance Report	July/yearly	N/A	INFO	External release
Operations, Monitoring, and Maintenance Report[1]	TBD	TBD	45	Primary

a. Deliverable date (to be determined) set in the MNA Zone 1 Remedial Action Report.
FY = fiscal year
INFO = for information
ISB = in situ bioremediation
MNA = monitored natural attenuation
TBD = to be determined

ID	Task Name	Start	Finish
1	**MNA RD/RA Work Plan**	**Thu 8/1/02**	**Fri 6/11/04**
2	MNA Work Plan Preparation	Thu 8/1/02	Fri 1/31/03
3	Submit Draft MNA Work Plan	Mon 3/31/03	Mon 3/31/03
4	Agency Review of MNA Work Plan	Mon 2/3/03	Tue 6/3/03
5			
6	Prepare MNA Operation Manual	Fri 8/1/03	Tue 9/9/03
7	Pre-Final Inspection	Mon 9/15/03	Fri 9/19/03
8	Prepare Pre-Final Inspection Report	Mon 9/22/03	Mon 12/15/03
9	Agency Final Inspection and Report	Tue 12/16/03	Fri 6/11/04
10			
11	**Performance Operations**	**Tue 10/1/02**	**Mon 5/29/28**
12	FY03 Annual MNA Sampling/Analysis	Tue 10/1/02	Fri 2/27/04
13	FY03 Annual MNA Report	Mon 3/1/04	Fri 7/30/04
14	FY04 Annual MNA Sampling/Analysis	Wed 10/1/03	Fri 2/25/05
15	FY04 Annual MNA Report	Mon 2/28/05	Fri 7/29/05
16	Model Verification Report	Mon 4/18/05	Fri 9/30/05
17	FY05 Annual MNA Sampling/Analysis	Fri 10/1/04	Tue 2/28/06
18	FY05 Annual MNA Report	Wed 3/1/06	Fri 7/28/06
19	FY06 Annual MNA Sampling/Analysis	Mon 10/3/05	Wed 2/28/07
20	FY06 Annual MNA Report	Thu 3/1/07	Mon 7/30/07
21	FY07 Annual MNA Sampling/Analysis	Mon 10/2/06	Thu 2/28/08
22	FY07 Annual MNA Report	Fri 2/29/08	Tue 7/29/08
23	FY08 Annual MNA Sampling/Analysis	Mon 10/1/07	Fri 2/27/09
24	FY08 Annual MNA Report	Mon 3/2/09	Wed 7/29/09
25	FY09 Annual MNA Sampling/Analysis	Wed 10/1/08	Fri 2/26/10
26	FY09 Annual MNA Report	Mon 3/1/10	Wed 7/28/10
27	FY10 Annual MNA Sampling/Analysis	Thu 10/1/09	Mon 2/28/11
28	FY10 Annual MNA Report	Tue 3/1/11	Thu 7/28/11
29	FY11 Annual MNA Sampling/Analysis	Fri 10/1/10	Tue 2/28/12
30	FY11 Annual MNA Report	Wed 2/29/12	Fri 7/27/12
31	FY12 Annual MNA Sampling/Analysis	Mon 10/3/11	Thu 2/28/13
32	FY12 Annual MNA Report	Fri 3/1/13	Tue 7/30/13
33	Prepare Remedial Action Report Zone 1	Fri 3/1/13	Thu 9/26/13
34	Submit Draft RA Report Zone 1	Mon 9/30/13	Mon 9/30/13
35	Agency Review RA Report Zone 1	Mon 9/30/13	Tue 1/28/14
36			
37	Annual Sampling for Zone 2 Wells	Tue 10/1/13	Mon 9/27/27
38	Remedial Action Report Zone 2	Tue 9/28/27	Mon 5/29/28
39			
40	**Long Term Operations**	**Tue 10/1/02**	**Tue 1/1/41**
41	Long-term Operations Zone 1	Tue 10/1/13	Tue 1/1/41
42	Long-term Operations Zone 2	Thu 6/1/28	Fri 11/30/40
43	Long-term Operations Zone 3	Tue 10/1/02	Fri 12/28/40

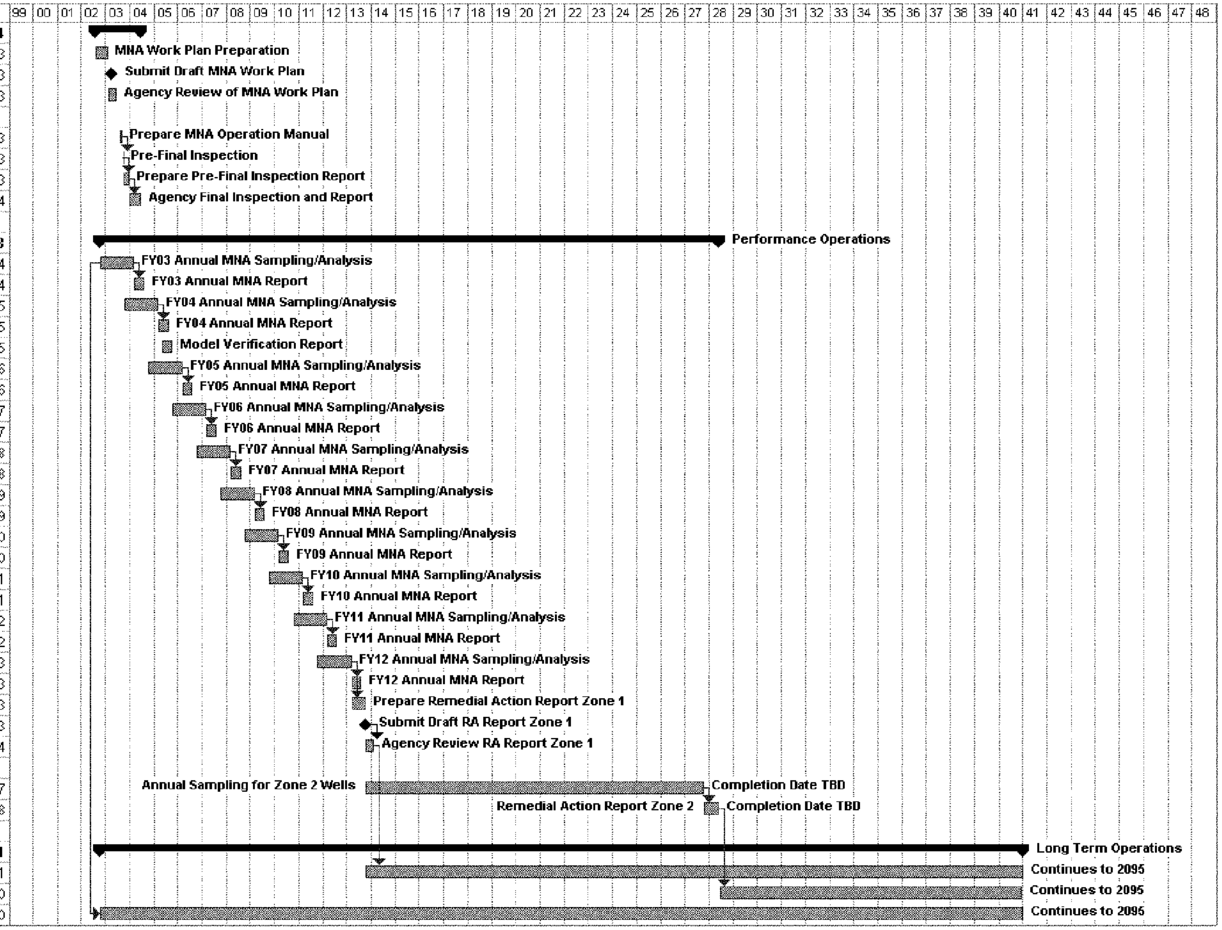

Figure 13-1. Remedial design/remedial action schedule for monitored natural attenuation.

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